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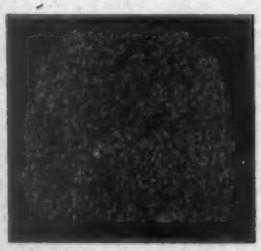

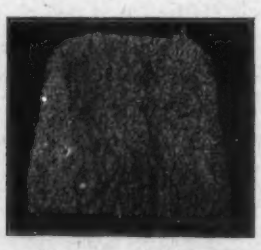

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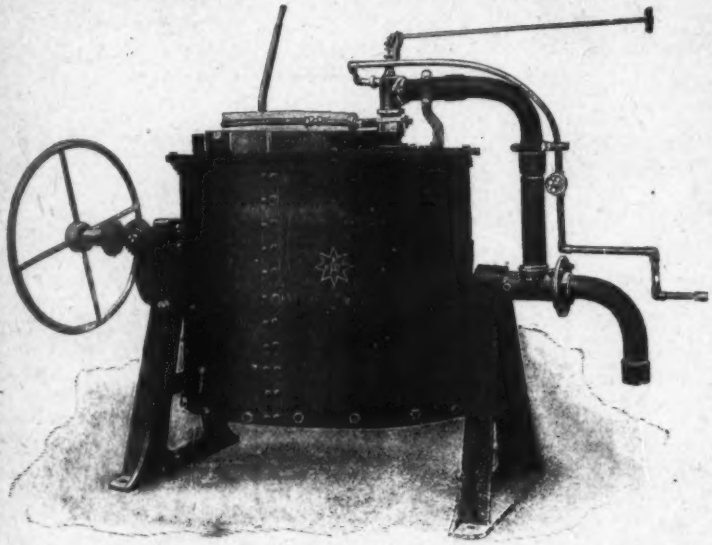

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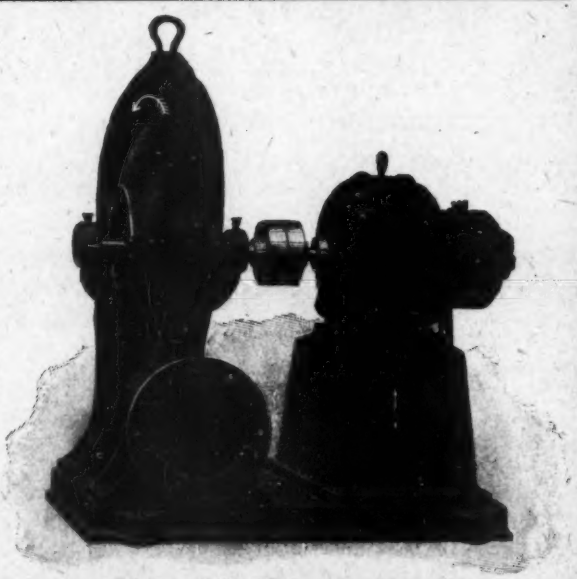

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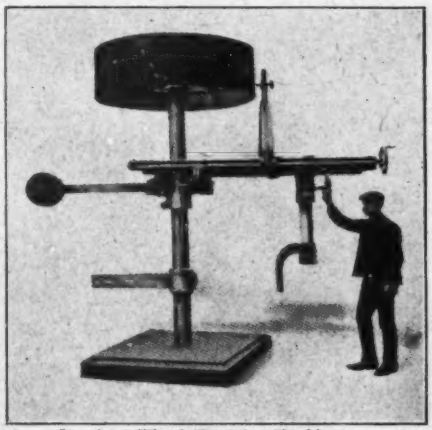

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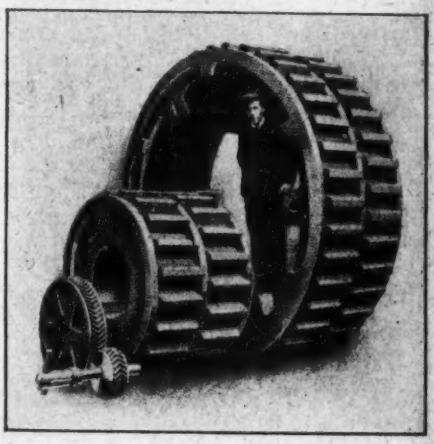

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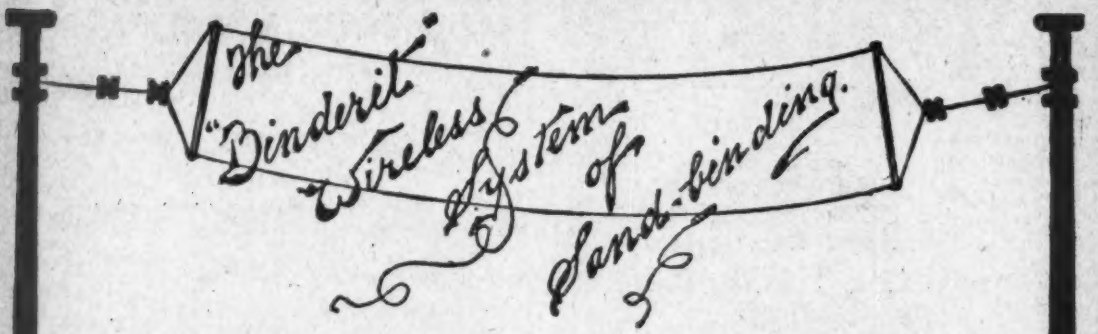

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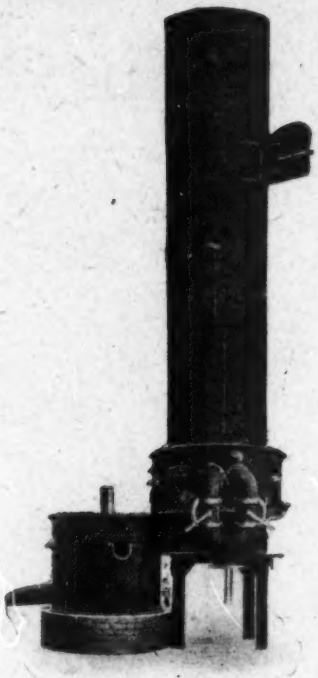

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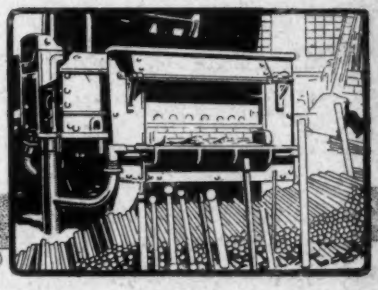

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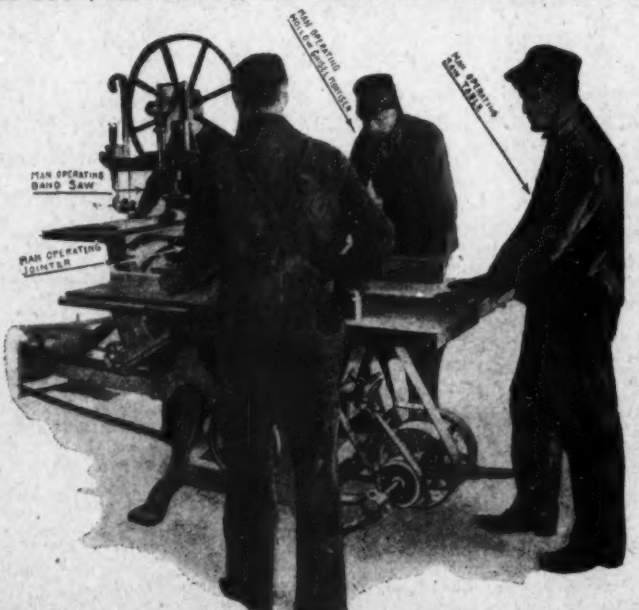

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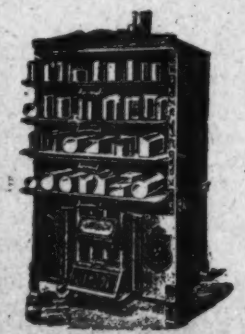

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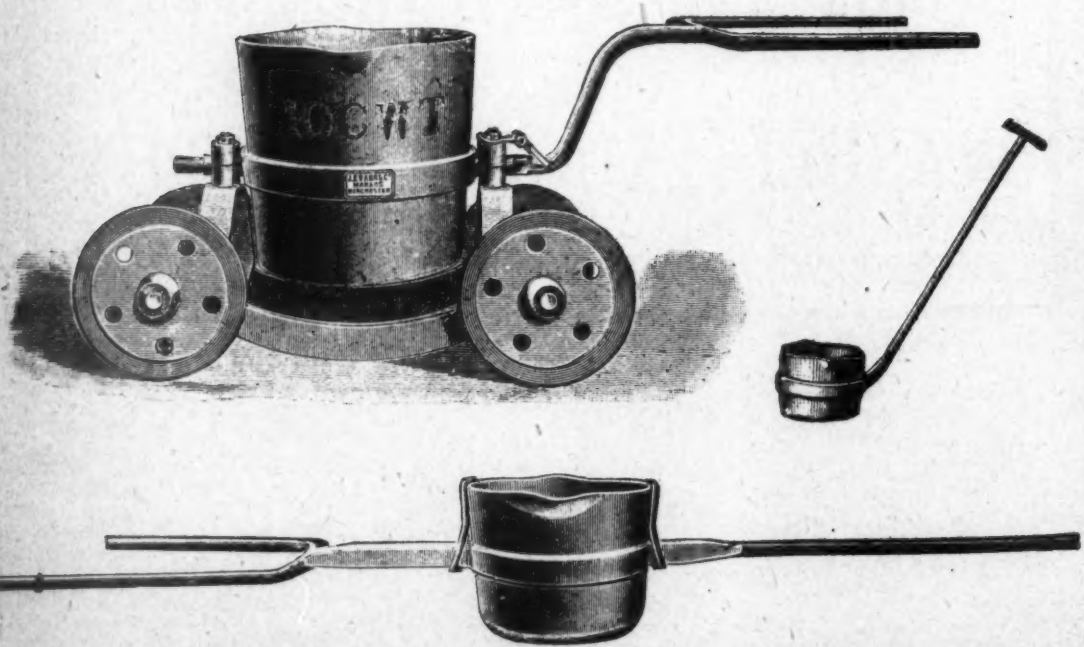

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Vol. 18. JANUARY, 1916. No. 169

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British Foundrymens' Association (East Midlands Branch).—"Brasses and Bronzes," by H. L. Reason.

JANUARY 29.

British Foundrymens' Association (Newcastle-on-Tyne Branch).—Lecture by Professor A. Campion (Glasgow).

FEBRUARY 5.

British Foundrymens' Association (Lancashire Branch).—"Some Unorthodox Patterns," by J. R. Moorhouse.

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British Foundrymens' Association (Scottish Branch).—"Notes on Cupola Practice," by R. B. Robinson.

FEBRUARY 18.

British Foundrymens' Association (London Branch).—"Some Scientific Considerations in Steel Founding," by W. A. Naish, A.R.S.M., A.I.M.M.

NOTES AND COMMENTS.

British Trade Abroad.

To state that at the conclusion of the war every effort will have to be made to expand our exports to foreign countries is to remark on the obvious; but when the question of methods and business enterprise is discussed one finds that in many directions changes will have to be initiated. There are some who are inclined largely to credit Germany's economic progress to Government aid; and undoubtedly to some extent that has been a very useful factor, though we are inclined to think that it alone would have had little effect. Co-operation of the Government of a country and its officials abroad requires to be supported by energy and enterprise on the part of manufacturers and their representatives. In some markets the latter have failed by reason of lack of information and support from our Government representatives, but in other cases the efforts of our commercial attachés have been expended to little purpose through manufacturers lacking enterprise. These factors, and also the present banking systems of the country (which are certainly not conducted on the basis of expanding British commerce abroad), require to be taken into consideration in the future.

With regard to Government aid, Mr. H. P. Rowell, discussing the industrial situation before the North-East Coast Institution of Engineers and Shipbuilders, remarked that one outstanding result of the war would be a marked change in the attitude of all departments and sections of our Government towards the trade and manufactures of the country, and with regard to education as bearing on these. "It is quite comprehensible," he said, "that the political representative of this country may consider that he cannot properly assist a particular British subject to secure an order, but it is wrong that he should not realise that it is of first importance that the country he represents should secure the order. In my personal experience, after having secured an order I have known the German Ambassador go to the ruler of the country to get it cancelled. On the other hand, I have been told by a similar British representative that he could take no interest in the securing of orders, even for warships, by British subjects unless he could be satisfied that irregularities were occurring, and that while this was not the case he had no concern in the nationality of the successful firm. I think it is not too much to say that such an attitude, much less such an expression of opinion, would have been extremely likely to lose a German Minister his post. Most of our important Embassies have now commercial attachés, who in many cases are men of exceptional energy and ability, and who are doing excellent work. The extent to which they are supported personally, however, by the diplomatic side of the Embassy is a matter which might be investigated with advantage to them and to the country they are endeavouring to serve."

It is agreed that intervention in affairs of business by a diplomatic agent is not likely to commend itself to that body, and if exercised in favour of one British firm against others would be grossly unfair; but every order secured by

this country is a commercial benefit to the country. Further, where a firm does show enterprise and initiative in cultivating a foreign market, it might fairly be expected that the nation's employés—to wit, the consular and diplomatic representatives—would render all possible aid by way of influence and information, without discriminating between British firms as such. It is a stupid and costly affectation for the services in question to dissociate themselves from the commerce of their nation, as they are too often fond of doing.

Overtime and Output.

The value of persistent "overtime" in works operations is a subject which at present calls for careful consideration; for under pressure of war necessity and the urgent demand for output, many works have for months been operating almost continuously. There are, of course, certain trades which necessitate continuous day-and-night operation and in such cases suitable shifts are arranged, each representing a normal day. But as the pressure on some trades is intermittent and does not justify continuous working, the practice of working "overtime" or excess hours over the normal day is adopted. It might at first seem that since the overhead expenses are not increased this extension of the producing hours would make for economy. In practice, however, it will be found that overtime and long hours are not economical in any trade which demands individual skill, initiative or energy on the part of the men.

There is for every man a restricted number of hours during which he can continuously follow the same occupation, at the same rate and with the same accuracy. Under the influence of enthusiasm or other excitement, that number of efficient hours may much exceed the normal working day for a short period; but it involves drawing on the man's reserve of energy and cannot be continued indefinitely without opportunity to recuperate. The nature of the occupation, too, is a factor in determining the efficient period of working, which accordingly varies with different trades or occupations. But it is fairly safe to affirm that the working day which practice has established as normal cannot be materially exceeded and efficiency maintained. There are exceptional conditions which may demand excessive overtime for short periods, and where the result justifies the departure. Most break-down jobs in engineering, for example, pay for overtime by reason of involving other considerations than mere efficiency in production. But manufacturing operations employing skilful craftsmen are not in the same category.

When fatigue, mental or physical, becomes considerable, as after many hours' work, the worker's reaction time increases—his body ceases to respond readily to the dictates of the brain—and consequently he works slower. If, then, the working day is lengthened unduly, the worker starts the next day's work unfit for fully efficient operation; and it is quite possible by lengthening the day's work to actually reduce the output of a plant which is dependent on the skill of the men rather than on machine operation. An additional consideration, particularly in such plants as foundries, is the increased risk of accidents when the men are fatigued—a risk involving the work as well as the men.

It would, of course, be absurd to claim that the normal working day should never be exceeded; but it is certainly the case that the output of many foundries could be better and more economically increased by turning attention to proper tools, appliances and machinery than by making excessive demands on the capacity of the men. With the present shortage of labour a compromise involving proper equipment and supervision, coupled with the least possible extension of the working day, would generally give the best results. There is little possibility of avoiding overtime under present conditions, but every attention should be paid to all other possible means of increasing output, so as not to decrease the efficiency of the men unduly.

Installation of New Foundries.

The foundry trade is much to the front at present, and many engineers who in the past have paid little regard to the foundry (except to regard it as a more or less necessary nuisance) now contemplate starting such a plant as an adjunct to their works. This is particularly the case in regard to non-ferrous work, for brass and bronze casting can be conducted on a more modest scale than iron founding. It is not for us to discuss the advisability of starting new foundries at the present time, for the immediate prospects of remunerative employment and the possibility of making good use of the plant later must essentially differ in individual instances. But when it has been decided that a new foundry is justified by present and future prospects, the procedure requires mature consideration, or it may result in sad disappointment. Founding is not a fool's game if it is to be conducted as a commercial affair, and more than a casual knowledge of the business and technical sides of the trade is necessary. Even when the business man has satisfied himself that there are orders to be booked at a remunerative price, the subject must be weighed up in the light of installation costs and the capacity of the plant to handle work and expand if necessary.

First, then, it is necessary to form some idea of the probable output for the first couple of years, and construct a building that will nicely accommodate that output; but with a view to future developments the possibility of extensions of capacity must be borne in mind. It is not always the most compact and handy plant that is the most readily extended—in fact, it is often the reverse. Even if ground space and buildings are available for future developments, the lay-out for an initial installation may be a bad nucleus for growth. Care must be taken, then, to so dispose the various departments that future additions do not disturb the harmony of the plant. The unit system—in which sections of the whole foundry are self-contained—has much to recommend it, but is strictly more suitable for a definite manufacturing plant than a general foundry. With factory production growth of output can be almost automatically obtained by adding to the foundry units. But in general founding a different style of flexibility is needed.

In the matter of equipment, too, there is plenty of scope for the uninitiated to sink money in plant that will never be fully used, or, on the other hand, to hamper the producing capacity through lack of a relatively small outlay on proper appliances. Where a considerable variety of alloys is to be handled in small quantities, a battery of small coke-fired pit furnaces is often a valuable feature of the plant, particularly if supplemented by furnaces of a larger capacity. Where the quantities of one alloy justify it, modern tilting furnaces—coke or gas fired—are often suitable and lend themselves to economical production. Moulding machines, handling appliances and runway systems, and a number of other oft-desirable features of foundry equipment may be valuable or practically useless according to the amount and class of work and also the disposition of the foreman to utilise them. It is good policy in starting a new foundry to secure the foreman first, if possible, and then embody his suggestions as far as reasonable in the scheme as developed. This would often save much unnecessary outlay on plant that is not suitable to the work, apart from avoiding friction in the future. Failing that, recourse can generally be had to some one with the necessary knowledge of the requirements of founding to indicate the most suitable procedure.

The Moulding of a Condenser Body.

By "Tubal Cain."

The following article describes the casting of condenser bodies in the largest foundry in Australia, at Castlemaine, Victoria :—

It is usual to sweep up condenser bodies in loam, but in the instance now described the design and dimensions of these particular castings induced a departure from the usual methods, and they were rammed up in sand. We were further influenced by the fact that in addition to 24 bodies there were also 24 water ends required, and we were able to make an iron pattern do service for both moulds. The water ends were 18 in. deep, so the pattern was made the exact depth required. Another advantage gained by one pattern for both castings was the perfect matching when the castings were bolted together on completion.

On starting the job a strong foundation plate was made with dabbers cast on 18 in. long, and all necessary lugs, both interior and exterior, were cast on to facilitate the bolting down when ready for casting. This plate weighed 6 tons, and was levelled in its position on the floor to remain until the completion of the order. These other dabber plates were required for the exterior, and they were made as required.

A centre to take a 3-in. spindle was fixed in the floor for the purpose of squaring and adjusting the pattern; this is shown in Fig. 1. The main core plate for lifting the interior is also shown in Fig. 1, and also some of the bolts for securing the grids (shown in Fig. 2) in the shute section of the main core. Before any part of the pattern is placed in position, it is necessary to make a seating for the main core plate; this plate is 3½ in. thick, and has three stout loops cast in it for lifting purposes, also a row of 1-in. bolts on the shute side. This plate is well bevelled to allow it to be withdrawn from its seating without damage to the bottom of mould. The bed or bottom face of the mould is made simultaneously with the seating of the core plate, and in this are placed several iron packing pieces right on to the foundation plate; these are to prevent the iron pattern from sinking into the face of the mould.

With the core plate in its seating we start the mould by adjusting the iron pattern on its bed. A complete pattern of the bottom flange is provided in sections

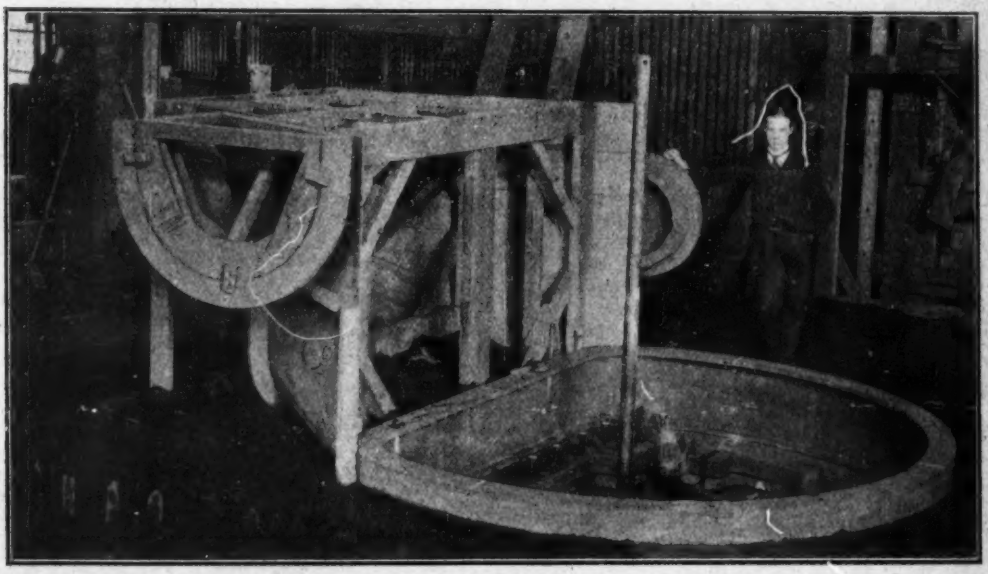


Fig. 1.

and this is also placed in its position round the iron pattern. The shute part of pattern shown in Fig. 1 is of a semi-skeleton type, and this is placed up to the iron pattern and held in position by packing. Before ramming is started the iron and wood patterns are carefully checked, squared and adjusted by the aid of the 3-in. spindle shown in Fig. 1.

The exterior of the mould is now rammed to the top of the iron pattern, and it then becomes necessary to draw the pattern a stage, and also to add No. 2 dabber plate, as shown in Fig. 4. As the pattern is drawn a stage so it must be carefully checked and squared to the spindle. The main runners or in-gates are now set in their positions one on each side of the outside flange of the shute and near the bottom. As the ramming proceeds dabber plates Nos. 3 and 4 are placed in position. The iron pattern is drawn by several stages until the full depth of the exterior part of the mould is complete. The iron pattern is then finally withdrawn, a strickle is secured to the spindle, and the circular part of the mould is trued up and just a slip of fine loam added. While

this is desirable it is not always necessary, as the pattern leaves the mould in good order.

The wood or shute part of the pattern is now withdrawn, but all bosses, brackets, ribs, facing strips, etc., are left in their place, and some of these, including the feet, can be seen in Fig. 2. Strips of proper thickness are now placed around the mould and all is made ready for the ramming up of the interior of mould or what is

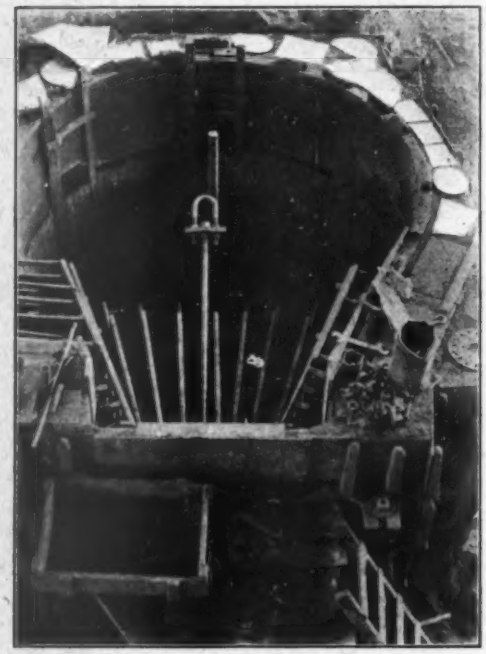


FIG. 2.

termed the core. The main core plate being in its seating and the thickness strips likewise in order, grids and plates are bolted on to the main core plate to carry the large body of sand in the shute. These grids rest in a cast-iron slotted frame, and this frame rests on a solid foundation in the print of the shute. To this frame is attached a 1½-in. bolt, with an adjustable shackle, which is shown clearly in Fig. 2, as are also the grids and plates of the shute, likewise the thickness strips around the circular part of mould.

The ramming of the core now proceeds for about 12 in., when the thickness strips are drawn a stage, and additional dabber plates in sections are placed round the circular part. These plates, although somewhat similar to the exterior plates, are made in short sections to facilitate the release and stripping of the casting, and with one or two exceptions the whole of these plates and grids were used from the start to the finish of the 24 castings. The wall of the circular part of the core is about 12 in. thick, and the inside of this wall is supported by wrought-iron plates rolled to the proper circle and fitted inside the dabbers. As the ramming proceeds further plates are added, and the thickness strips are drawn until the top of the mould is reached. All dabber plates have slotted lugs which are secured and bolted, and when all is complete a rigid and compact core is formed, which with care can be lifted about without showing sign of crack or springing.

As the exterior and interior are now rammed up to the full depth, it is necessary to ram up a top part or cope on what is called the web of the shute. This cope or top part is 12 ft. by 7 ft., and covers the whole of the web and part of the top flange; it also has the two main runners through it as well as a few risers. The top part is rammed and staked in the usual way and lifted clear, and when finished is stoved. That portion of the mould not covered by the top part or cope is covered by two circular plates, which are seen in position in Fig. 4. These plates are about 18 in. wide, and in them are cast a few 3-in. holes for risers.

As far as possible all thickness strips are now withdrawn, which leaves a clearance for the core or interior of the mould to be lifted out of its seating, and as this core weighs about 14 tons, it is necessary to have strong tackle. The chains are adjusted to the two central lifting loops (one of which can be seen in Fig. 1) in the core plate, a third is adjusted by a turnbuckle, and the fourth to the shute portion of the core by the screw shackle shown in Fig. 2, and when all the chains are taut the core is lifted out of its seating and placed on the stove carriage ready for finishing and drying.

The remainder of the thickness strips in the shute can now be removed and the whole of the mould finished and blackened ready for drying, and this is done by building a fire of wood logs in the centre of the mould after the core seating has been well protected from damage. With one night's drying the mould is ready for all small and large cores such as the branches, feet, etc., to be put in their respective prints and positions. The mould then receives another firing, and the following morning after cleaning out is ready for the reception of the main core.

The core is again lifted and carefully plumbed, and Fig. 3 gives a good view of it ready to be lowered into position. A few lighted candles are placed at the bottom of mould, and it is usual to have half-a-dozen hands to steady the core while being lowered into its seating. This operation usually occupies 15 minutes, and with the exception of the first casting it has not been necessary to

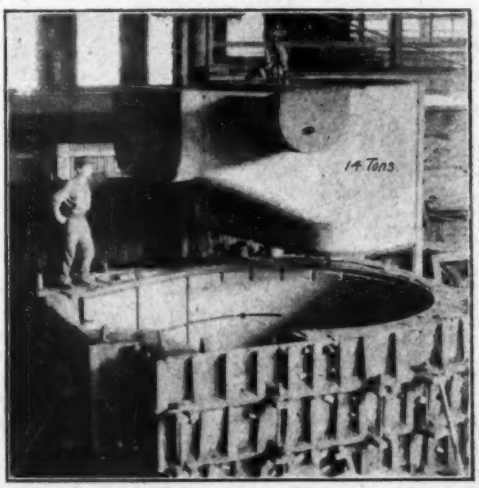


FIG. 3.

lift the core when once in its seating. The print of the shute is now rammed up when all vents are secure, the top part covering the web is lowered into position and the two circular plates which cover the flange and top of mould are put in their place.

The mould now being closed, it has to be well secured for casting, and a good many rails and bolts are used in the operation, as shown in Fig. 4. A runner box is placed on the 12-ft. by 7-ft. top part and a runner basin with a capacity of about 1 ton is made up, also all risers and feeder heads.

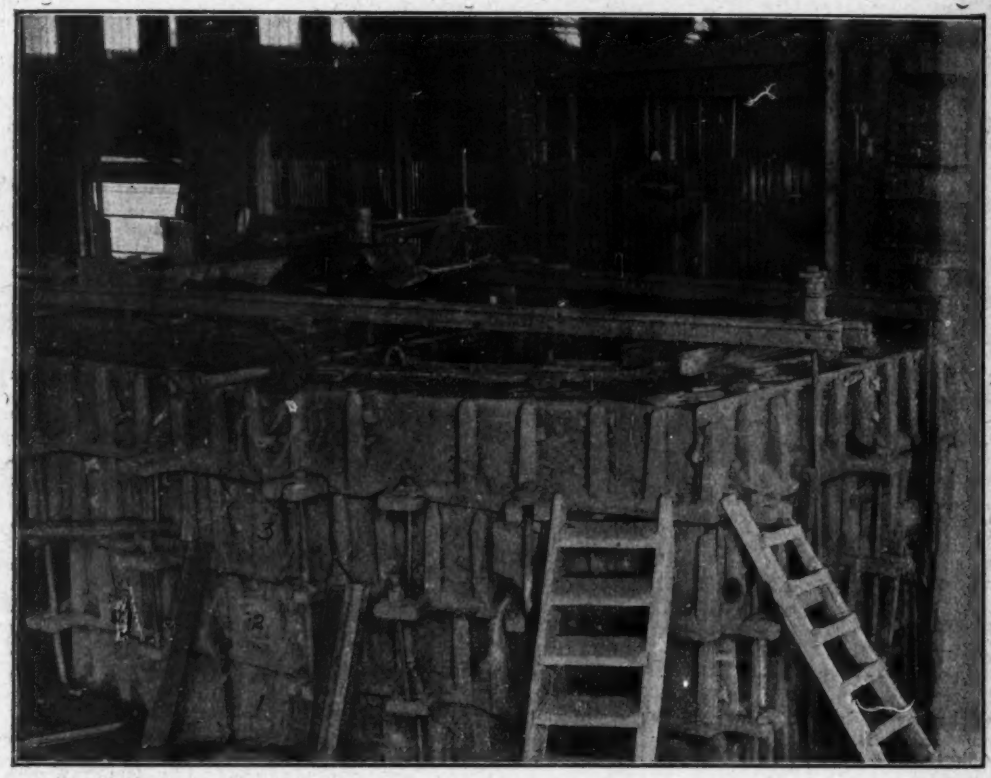


FIG. 4.

The method of casting is with a 9-ton ladle at the main runner and a 1-ton ladle at the opposite side of mould. As soon as the casting is set we start to strip the inside, as it is essential for the core to be released to allow contraction. The top part and top circular plate are removed, and all the dabber plates used for the core have to be unbolted right down to the seating, and when this is done practically the whole of the tackle used in the building of the core can be removed by the crane with ease, and is usually done in about one hour. The main core plate is not removed, as this is below the bottom of the casting and does not interfere with the contraction. All exterior plates are removed and the casting is usually in the hands of the dressers in 18 hours from the time of casting. Fig. 5 shows the casting.

So far 24 of these castings have been made and carted 78 miles by rail to their destination. A very satisfactory feature of the job is the perfect matching of the bodies and water ends, and while different methods of moulding could be adopted, better results in the matching could not be obtained. The complete order comprised 24 half-bodies, 24 water ends, and 24 end covers, and when complete formed 12 condensers, which is said to be the largest single condensing unit in the Southern hemisphere.

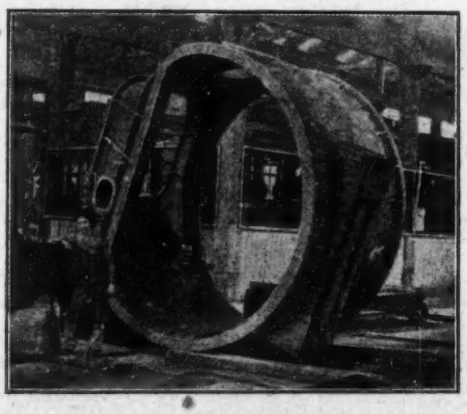


FIG. 5.

PATTERN METAL.—A useful formula for a non-shrinkable white metal for use in making metal patterns is as follows:—Tin, 45 per cent.; lead, 45 per cent.; antimony, 5 per cent.; bismuth, 5 per cent. The foregoing mixture melts very easily and should not be poured too hot, as it runs very freely at a low temperature.

Cast Malleable Iron and Cast Steel.*

By A. Harley.

Being concerned in the manufacture of both malleable cast iron and mild-steel castings, the writer has not only had to reflect very often on the different processes involved, but also to compare the characteristics and relative merits of the two metals.

Broadly speaking, the subject in which we are interested is the production of light castings in malleable iron and in mild steel. The writer's experience of recent years has been in the production of castings for the motor and cycle trade, and the following remarks naturally apply more particularly to that class of work. Such as it is, the field is a vast one, and it is obviously impossible in the time at disposal to cover the ground even in the most

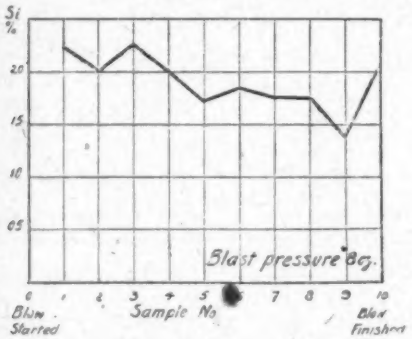


FIG. 1.—GRAPHIC REPRESENTATION OF LOSS OF SILICON THROUGHOUT MELT IN CUPOLA.

general manner. It is therefore proposed (a) to mention a few general considerations; (b) to deal with the production of molten metal; and (c) to put before you a series of tests made on cast malleable iron and cast steel.

General Considerations.

Among foundrymen sharp differences of opinion exist concerning the best methods of production, and among both foundrymen and engineers there is considerable diversity of opinion as to the relative merits of the two metals as applied to various purposes. With regard to the former, these differences of opinion occur at every stage of production. One man puts his faith in certain brands of iron; another may not worry about the particular brand if the analysis is according to his liking. One man will say that good malleable cast iron cannot be made with cupola metal; another will affirm that he is doing it. On the moulding floor one man favours the use of chills; another places a feeder wherever he thinks it necessary and sometimes where it is not.

In regard to annealing malleable cast iron, no two men think alike. One man will swear by round ovens; another will swear at them. One man believes in soaking; another will ask how it is possible under the present restrictions; and so on.

One engineer recently advocated the employment of malleable cast-iron in preference to cast steel for motor-lorry road wheels. The suitability of the metal was not only emphasised, but a great point was made of the greater ease and lower cost of production. My experience would lead me to differ on both counts. First, I doubt whether malleable is at all suitable for such a job; and secondly, I am decidedly of opinion that in this particular instance a steel casting of high quality could be produced more cheaply than a malleable-iron casting.

The engineer has to weigh up all the pros and cons in coming to a decision, and one of his chief considerations is, undoubtedly, the question of cost. The cost, or rather selling price, has a good deal to do with the question of quality. The cult of cheapness can be carried too far. The "malleable" trade particularly has suffered from this very thing. The cutting of prices has not always been accompanied by a reduction in cost due to improved methods of production. More often the reduction in cost has been accomplished by the use of inferior material. The buyer is not free from blame in this matter. With too many, orders are placed at the lowest price irrespective of quality. They have acted on the principle that "malleable iron is malleable iron all the world over." People sometimes get what they pay for.

In fact, the design not only influences cost, but very often the quality of the casting, too. The foundryman should be consulted in this matter, and in an efficiently-managed concern this is done, and alterations suggested are made where possible. Even when the best has been done with a design, in most cases there will still be plenty to engage the foundryman's skill.

With regard to the relative cost of malleable iron and steel castings, it is difficult to make a definite pronouncement. For very light work, say under ⅜-in. section, the cost tells against steel; over this section, in favour of steel. This is necessarily a rough generalisation, as obviously much depends on the size and shape of the casting.

The actual foundry cost is not the only point to take into consideration. At present, greater machining allowances are required for steel. On the other hand, the greater strength of steel allows a relatively lighter casting to be used.

For certain classes of work—such as cycle parts—a fine skin is absolutely essential, as the majority of such parts have not only a very small machining allowance,

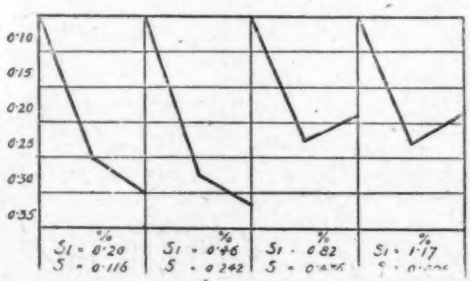


FIG. 2.—SHRINKAGE OF MALLEABLE CAST IRON.

but subsequently have to be enamelled or plated, wherel y any irregularity on the surface would be intensified. Malleable cast-iron, therefore, is in favour for such work, but progress is being made with steel in this respect. A point in favour of steel is the quick delivery that can be effected.

Cupola Melting of Malleable Cast Iron.

Broadly speaking, the particular melting method adopted is governed by the class of work and the output to be handled. Certain prime essentials are necessary

* Read before the Birmingham Branch of the British Foundrymen's Association, November 27, 1915, Mr. J. Shaw in the chair.

in every furnace melting any metal on a commercial scale. All foundrymen are acutely aware of what these essentials are. The metal must be of ample fluidity, correct and regular in composition, and produced at a reasonable cost.

Dealing with malleable cast iron first, the three principal types of furnace in use are:—(1) The crucible furnace; (2) the reverberatory or air furnace; (3) the cupola.

The air furnace is used chiefly in the production of black-heart malleable. In the production of Reaumur malleable the cupola and crucible furnace are almost universally used. Where the output justifies it, the cupola should have preference. The crucible furnace is usually credited with giving better quality metal than the cupola. This may be so, although it is not altogether obvious why it should be so. It may be due to the fact that the percentages of carbon and silicon are not subject to so much alteration in the process of melting. On the other hand, it has always seemed to the writer that variations in the iron as delivered were more likely to be perpetuated in the molten state when

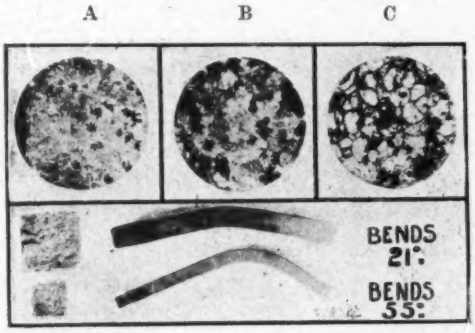


FIG. 3.—ENGLISH BLACK-HEART MALLEABLE CAST IRON. A, EDGE, AND B, CENTRE, POLISH ATTACK; C, CENTRE, ETCHED.

Bar	C.T.	C.C.	C.G	Si.	S.	P.	Mn.
1″ ..	2.57	Tr.	2.57	0.66	0.034	0.11	0.40
½″ .	2.60	Tr.	2.60	0.62	0.038	0.11	0.39
	US.	Yield.	%E	%C.	H.	Imp.	Batch No.
1″ .	13.93	11.70	5.0	10.75	131	7.5	1
½″ ..	15.90	12.09	13.39	11.64	90	6.5	

melted in the crucible furnace. Anyhow, the cupola furnace is much more economical to work, the metal can be obtained in a higher state of fluidity, and I am convinced that by taking certain precautions the metal can be obtained much more regular in composition.

In the production of malleable cast-iron, a uniform composition in the hard state is of the utmost importance. It is irregularities in the hard metal which lead to most of the difficulties in annealing. I do not advocate any particular analysis as being right and all the others wrong. The point to be emphasised is that, having decided on what is the most suitable composition for the class of work, the furnace should give (with reasonable limits) molten metal of that composition throughout the melt. Any change in the metal must be intentional and known, so that the castings subsequently can be graded and given the annealing treatment most suitable to their composition.

In the following notes will be described as shortly as possible the means which the writer has found it necessary to adopt to obtain this control. The exist-

FIG. 4.—BLACK-HEART MALLEABLE CAST IRON. A, EDGE; B, NEXT TO EDGE; C, CENTRE.

Bar.	C.T	C.C.	C.G.	S.	S.	P.	Mn.
1″ ..	2.50	Tr.	2.50	1.41	0.12	0.066	0.41
½″ ..	2.41	Tr.	2.41	1.42	0.12	0.07	0.40
	U.S.	Yield.	%E.	%C	H.	Imp.	Batch No.
1″ ..	14.04	—	—	—	116	2.5	1A
½″ ..	16.0	—	1.50	0.80	137	5.0	

ence of a laboratory or facilities for obtaining analyses is assumed, and also that the furnace is fairly correct in its proportions, and that there is an even supply of air at the correct pressure. Attention is thus confined to the raw material which goes into the furnace.

Pig-iron.—This must be bought to specification and adequately checked. We have found it advantageous to give each separate consignment a reference number. This number is not only attached to the heap of pig-iron in the yard, but is used in all subsequent records. A separate stock card is made out for each consignmennt. This card shows the analysis and also the usage.

Scrap.—This also must be graded according to analysis, the silicon content being sufficient as a rule. This grading of scrap is rather important, although it might be inferred that if the molten iron is regular in composition,

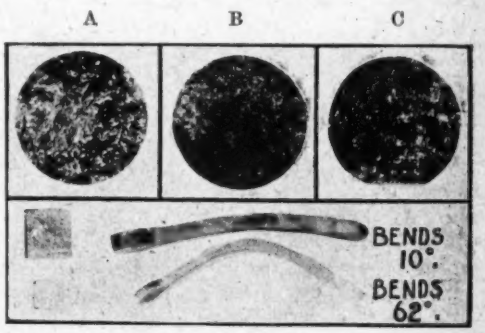


FIG. 5.—"BASTARD" BLACK-HEART MALLEABLE CAST IRON. A, EDGE; B, NEXT TO EDGE; C, CENTRE.

Bar.	C.T.	C.C.	C.G.	Si.	S.	P.	Mn.
1″ ..	3.26	0.82	2.44	0.90	0.29	0.03	0.11
	U.S.	Yield.	%E.	%C.	H.	Imp.	Batch No.
1″ ..	21.84	—	1.5	1.128	163	1.5	2
½″ ..	27.3	16.30	8.93	3.10	156	—	

the scrap will be so also. If the scrap is melted up daily, however, the composition of the metal will change, due to the fact that a certain portion of the metal is, of

necessity, melted over and over again. To keep perfectly straight, small daily adjustments would be necessary in the virgin pig used. To avoid this, the scrap from one mix is accumulated so long as that particular mix is in

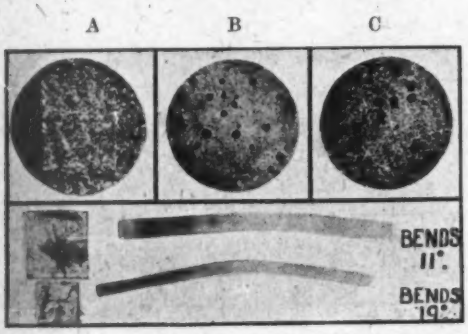


FIG. 6.—REAUMUR MALLEABLE CAST IRON. A, EDGE (FERRITE); B, NEXT TO EDGE (PEARLITIC); C, CENTRE (CEMENTITE NETWORK).

Bar.	C.T.	C.C.	C.G.	Si.	S.	P.	Mn.
1" ..	2.55	1.05	1.50	0.59	0.36	0.054	0.13
½" ..	2.30	1.08	1.22	0.58	0.39	0.054	0.11
	U.S	Yield.	%E.	%C	H.	Imp.	Batch No.
1" ..	17.40	—	1.00	1.48	169	1	3
½" ..	24.0	—	6.7	2.7	149	1	

use, If the silicon has been kept fairly regular, this heap of scrap can be incorporated in the mix at a subsequent date, with the comfortable feeling that you know what you are using. If the silicon content has radically altered through some unforeseen cause, this is quickly known by the daily analyses of the cast metal, and both

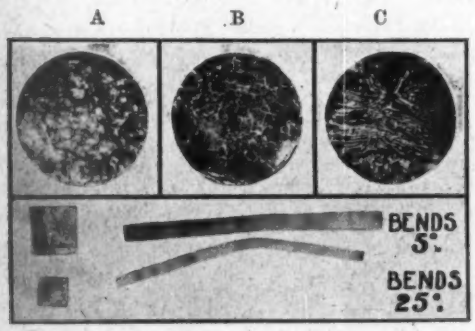


FIG. 7.—REAUMUR MALLEABLE CAST IRON. A, EDGE B, CENTRE; C, CENTRE AT 1,200 DIA. MAG.

Bar.	C.T.	C.C.	C.G.	Si.	S.	P.	Mn.
1" ..	2.64	0.81	1.83	0.52	0.50	0.066	0.09
½" ..	2.03	0.98	1.05	0.56	0.46	0.067	0.11
	U.S.	Yield.	%E.	%C.	H.	Imp.	Batch No.
1" ..	22.6	—	—	—	179	1	4
½" ..	24.8	—	1.0	0.976	183	2	

castings and scrap with this altered silicon are separated from the normal metal.

Coke of the best quality must be used. The sulphur, particularly, should be as low as possible. Ordinary English malleable pig-irons usually contain a pretty high percentage of this element, and it is undesirable to increase this by any appreciable amount. The coke also should be uniform physically. The coke we are using at present shows the following average composition:—Fixed carbon, 93.65 per cent.; ash, 5.65 per cent.; sulphur, 0.70 per cent.

Another coke shows a lower sulphur (0.53 per cent.), but a higher ash (8.60), and consequently a lower percentage of fixed carbon. It is not quite so good as the first in physical qualities.

Definite knowledge must be acquired with regard to the inevitable changes that take place in the composition of the metal during the melting process. These changes must be allowed for. The elements affected are carbon, silicon, and sulphur. The amounts of these elements present, and so the relative proportions, largely determine the annealing treatment required. We have found that these losses and gains vary throughout a heat. With silicon, for instance, the loss in our practice at the beginning is 0.23 per cent. This will diminish fairly

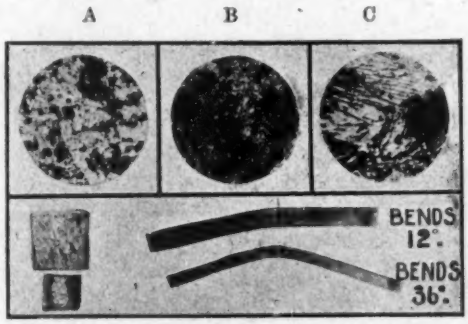


FIG. 8.—HIGHER SILICON REAUMUR MALLEABLE CAST IRON. A, EDGE; B, CENTRE; C, CENTRE AT 1,200 DIA. MAG.

Bar.	C.T.	C.C.	C.G.	Si.	S.	P.	Mn.
1" ..	2.97	0.86	2.11	0.72	0.39	0.045	Tr.
½" ..	2.85	0.85	2.00	0.71	0.39	0.051	Tr.
	U.S.	Yield.	%E.	%C.	H.	Imp.	Batch No.
1" ..	18.95	17.15	1.50	1.128	149	2	5
½" ..	17.40	—	1.00	1.480	149	2	

regularly until 0.14 per cent. only is recorded. Then just at the end we may get a sudden jump back to 0.21 per cent. Sulphur acts in much the same way. At the beginning we get an increase of 0.07 per cent.; towards the end this comes down to 0.003 per cent.

The importance of good hot metal of suitable and regular composition cannot be over-emphasised. This applies to all metals, but very particularly to malleable iron and cast steel, and expenditure to secure this is amply justified. It is the foundation on which a good casting is made possible. Neglect or carelessness in this direction renders all subsequent care and skill useless. Many of the troubles that are usually put down to defects in moulding and core-making really originate in defective melting. In casting malleable iron, for instance, sears, cracks, draws, and blow-holes may be avoided to a considerable extent; but, over and above this, the successful annealing of malleable iron is only rendered possible by the metal being of suitable and regular composition.

The Annealing of Malleable Iron Castings.

The annealing of malleable iron requires a good deal of skill and experience, even when the hard metal is everything that it should be. There is no royal road to success in this process. Each man must work out his own salvation. The knowledge acquired from other people is no doubt useful, but the knowledge obtained from hard experience is the best.

The following observations on annealing are not put forward, therefore, as infallible dicta. They are, however, the result of practical experience, and may be helpful to some who are engaged in this most difficult business. A brief summary of the writer's views on the metallurgical process of annealing would run somewhat as follows:—"Any process in which equilibrium is established and maintained between the breakdown of the cementite and the diffusion of the carbon towards the exterior is likely to give satisfactory results."

The precipitation of carbon is governed more by composition than anything else. Take the influence of silicon, for example. With low-silicon metal of, say, 0.3 per cent., precipitation is retarded. With a high-silicon metal, on the other hand, precipitation may take place too soon, or, in other words, at too low a temperature. Very little carbon would be removed, and a kind of bastard black-heart material would be produced.

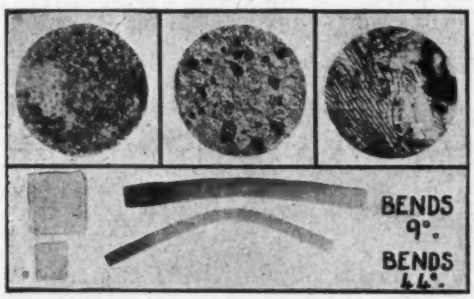


FIG. 9.—REAUMUR MALLEABLE CAST IRON. A, EDGE; B, CENTRE; C, CENTRE AT 1,200 DIA. MAG.

Bar.	C.T.	C.C.	C.G.	Si.	S.	P.	Mn.
1″ ..	2.33	0.85	1.48	0.67	0.42	0.059	Tr.
½″ ..	2.20	0.86	1.34	0.65	0.44	0.066	Tr.
	U.S.	Yield.	%E.	%C.	H.	Imp.	Batch No.
1″ ..	22.6	—	—	—	156	2	6
½″ ..	25.77	17.0	8.93	3.64	156	1	

As Hatfield has pointed out, there are two phases of this annealing process; first, elimination of carbon; second, softening of the interior by precipitation of the annealing carbon, and each phase must be accomplished at the proper time by establishing equilibrium. The treatment necessary to obtain this equilibrium will vary with the composition. The most favourable period for the removal of carbon is the one just preceding actual precipitation. Where the composition of the iron is such that precipitation may take place at a low temperature, equilibrium must be established between the removal of the carbon and the return of the annealing carbon into solution.

The influence of silicon and sulphur should be considered together, inasmuch as silicon favours the precipitation of carbon and sulphur retards it. It follows that the primary effect of either is modified by the relative amounts present. In fact, the influence of these constituents must be so regulated as to obtain the balance already mentioned between the rate of diffusion and the break-down of the cementite. To illustrate this

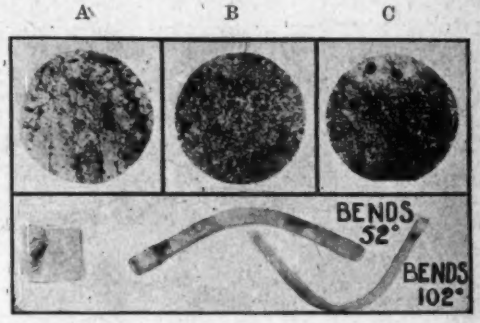


FIG. 10.—REAUMUR MALLEABLE CAST IRON. A, EDGE B, NEXT TO EDGE; C, CENTRE.

Bar.	C.T.	C.C.	C.G.	Si.	S.	P.	Mn.
1″ ..	1.93	0.73	1.20	0.50	0.47	0.032	0.066
½″ ..	1.52	0.27	1.25	0.50	0.49	0.033	0.06
	U.S.	Yield.	%E.	%C.	H.	Imp.	Batch No.
1″ ..	242	19.50	1.5	1.70	156	2.5	7
½″ ..	26.07.	21.08	8.93	3.70	131	2.0	

point, a low-silicon metal of, say, 0.3 per cent., which is quite annealable with 0.25 per cent. of sulphur, is almost unannealable with 0.5 per cent. of sulphur. On the other hand, a higher silicon of, say, 0.75 per cent. will give very indifferent results with low sulphur, the best results being obtained when associated with 0.45 per cent. These statements may not hold good where manganese is present to any extent.

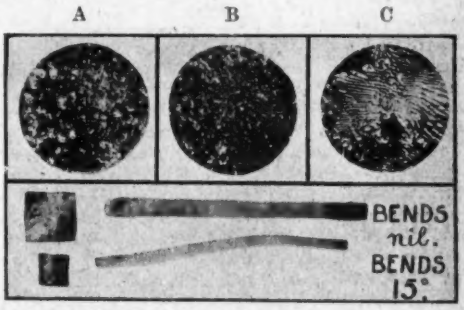


FIG. 11.—REAUMUR MALLEABLE CAST IRON. A, EDGE; B, CENTRE; C, CENTRE AT 1,200 DIA. MAG.

Bar.	C.T.	C.C.	C.G.	Si.	S.	P.	Mn.
1″ ..	3.30.	0.71	2.59	0.75	0.39	0.05	0.07
½″ ..	2.98	0.71	2.27	0.98	0.40	0.055	0.08
	U.S.	Yield.	%E.	%C.	H.	Imp.	Batch No.
1″ ..	24.72	—	—	—	169	2	8
½″ ..	18.80	—	—	—	149	2	

In most Reaumur metal the percentage of manganese is very low, as it ought to be. In black-heart metal from 0.4 to 0.5 per cent. is often present. In the absence of sulphur this no doubt serves a useful purpose in

retarding precipitation to some extent and enabling some carbon to be removed.

Many questions are always asked regarding the practical details in annealing; but all such practical details centre in the problem that has just been dealt with. The design of the oven naturally should give as even a distribution of heat as possible. There is no oven built in

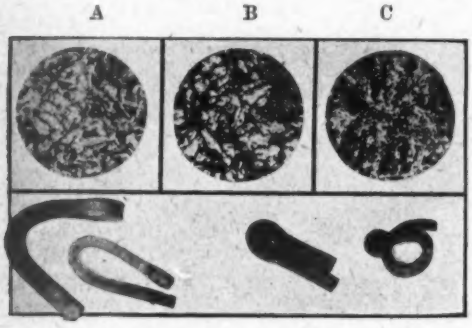


FIG. 12.—CAST STEEL FROM CONVERTER. A AND B, AS CAST; C, ANNEALED.

Bar	C.T.	C.C.	C.G.	Si	S.		Mn.
As cast ..	0.28			0.26	0.022	0.031	0.43
	U.S.	Yield.	%E.	%C.	H.	Imp.	Batch No.
As cast ..	32.23	23.18	8.59	23.42	150	13	9
As annealed	31.8	21.75	11.00	41.00	132	39	

which the heat is quite evenly distributed, and the writer has often been thankful for this. With large ovens there is generally a considerable variety of work, with varying sections. By exercising discretion in arranging the castings in the oven, a variety of work can be satisfactorily dealt with. Variations in the ore strength are also made to get over this difficulty. Where there is a battery of smaller-sized ovens, the castings can be more closely graded according to weight. A further advantage is that with such a battery considerable delays are avoided. Ovens are at all stages of firing and unloading, and an even flow in deliveries is secured. There are many advantages about such an arrangement, but one disadvantage is the somewhat higher cost of annealing.

If removal of carbon is too rapid, owing to excessive temperature and too strong ore, then the complaint known as "peeling" occurs. If the temperature is too low, or the ore too weak, then hardness results. With a medium-silicon iron in a coal-fired oven, the time necessary for diffusion is usually obtained by damping down for the night, or "soaking," as it is called; but similar treatment in a large gas-fired oven of, say, 10 tons capacity might not be satisfactory, owing to the longer time such an oven holds heat. In fact, removal of carbon may be taking place all through the night. In such a case the shutting down of the oven for 24 hours or so in the middle of the firing period would prove advantageous. If a high-silicon iron is used, the operation may be effected with a total fire, after coming up to heat, of 3½ days, even for the thickest section. In this period 1½ days would be spent in soaking or diffusing. The carbon removed is, of course, not very large, but for many purposes the "malleable" is quite satisfactory. If a better quality of iron is desired, the addition of two days to the firing time will produce the extra elimination of carbon which is necessary to give the superior quality to the material.

With reference to soaking, theoretically a continuous fire is no doubt quite possible, but practically we consider soaking advantageous. If the elimination of carbon is proceeding too vigorously it allows equilibrium to be established. It may be remarked, however, that the period in which to begin soaking does not necessarily synchronis with the hour at which the "bull" goes.

The size and shape of the pans, strength of ore used, the temperature and time taken, have all to be adjusted to the one end, but it must be borne in mind that many of such details are constantly changed, and necessarily so, according to the size, shape, and composition of the castings. In the writer's practice gas-fired round ovens are used.

In regard to ore, we use all strengths, ranging from all black to 3 to 1. The analysis of good annealing ore should approximately be as follows:—Ferric oxide, 84 to 90 per cent.; silica, 8 to 13 per cent.; lime should be absent; ferrous oxide should not, of course, be present, and anything more than 1 per cent. should be objected to.

The Production of Molten Steel.

In the production of molten steel of low carbon content we encounter a much stiffer proposition than in the melting of either malleable or grey cast iron. It is only in comparatively recent years that anything like success has been achieved. These remarks refer to mild steel capable of being run into light castings, many of them intricate in design. Further, the moulds are only skin-dried as a rule.

It is interesting to compare the melting temperatures:—For ordinary grey cast-iron, about 1,150 deg. C.; for malleable cast-iron, about 1,250 deg. C.; for mild steel, about 1,570 deg. C.

The pouring temperature is, of course, a different matter altogether. In the process about to be described, where a bulk of about 12 cwts. of molten steel has to be cast in one heat and into a large number of small moulds,

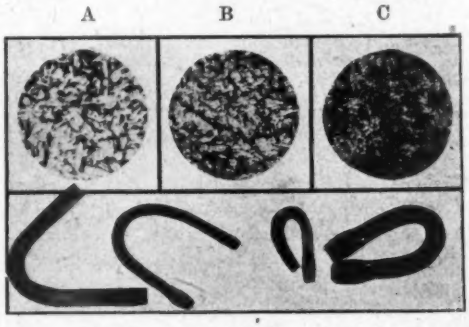


FIG. 13.—CAST STEEL. A AND B, AS CAST. C, ANNEALED.

Bar.	C.T.	C.C.	C.G.	Si.	S.	P.	Mn.
As cast ..	0.10			0.28	0.035	0.041	0.33
As annealed	0.095			0.22	0.025	0.034	0.24
	U.S.	Yield.	%E.	%C.	H.	Imp.	Batch No.
As cast ..	30.0	26.6	6.5	21.45	156	9.5	10
As annealed	27.10	16.18	41.64	74.36	116	30.0	

the temperature of the metal has to be very much higher. In fact, this must be in the neighbourhood of 1,900 deg. C. to do any good. In other words, a margin of at least 300 deg. C. to play with is required.

The general types of steel furnaces in use are the crucible furnace, the converter furnace, the open-hearth furnace, and the electric furnace. Each of these four represents a system in which there are many varieties.

The process of melting which is about to be described belongs to the converter system. The Bessemer converter is, of course, the father of all such types.

The chief modifications are that the hematite pig-iron, instead of being melted in a cupola, is melted in the converter itself. Also, instead of being blown from the bottom, as in the Bessemer converter, the metal is surface blown. The surface-blown method is also used in the Tropenas furnace, but in the latter case the pig-iron is melted in a cupola, as in the Bessemer process.

Small-capacity converters (say 10–12 cwts.) have been tried many times, but with varying success, the great difficulty being to obtain the metal of sufficient fluidity to cast the general run of light work in an automobile foundry. A larger-capacity vessel would no doubt give somewhat hotter metal at the moment of pouring, but a proportionately larger number of moulds would have to be poured, and before the finish a larger proportion of the metal would be unusable. Where castings of a considerable variety in weight are handled, this trouble would be obviated to some extent by grading the work on the floor. In passing, I may mention that we have found this grading of work quite essential to a successful cast. Under our conditions a small-capacity unit is the most suitable.

The melting of the charge in the vessel by means of an oil burner is an important factor in obtaining very hot steel. Before this operation is completed the lining has attained a very high temperature, thus conserving the heat created during the blow proper. Further, the escaping heat during the melt is used to heat a regenerative chamber. The air is passed through this chamber when blowing, and enters the vessel at a temperature of 300 deg.

All the previous remarks about care in the selection of raw material for malleable melting apply equally to steel—in fact, more so; and the writer doubts if it is possible to perform this job properly without knowing the exact composition of the hematite and also performing a carbon test for each melt. That is the minimum.

A typical analysis of hematite pig-iron to be used for conversion would be as follows:—T.C., 3.88 per cent.; C.C., 0.20 per cent.; G.C., 3.68 per cent.; Si. 2.53 per cent.; S., 0.04 per cent.; P., 0.04 per cent.; Mn., 1.10 per cent.

Consistently good results have been obtained from pig-iron of this composition, the steel pouring hot to the finish. Slight variations in the Si. and Mn. content are allowable, but if low it is advisable to add silicon-spiegel and spiegel to bring the composition to about the figure given. Further, silicon should not drop below 2.3 per cent., or manganese 0.8 per cent., if the molten steel is required to run very thin castings. The charge takes about two hours to melt and about twenty minutes to blow. The blast pressure for melting is about 1¼ lb. and the pressure for blowing 2½ lbs. at first, afterwards increased to 3 lbs.

Assuming that the blow is finished, the composition of the metal should approximate as follows:—C., 0.1 per cent.; Si., trace; Mn., nil; S., 0.04 per cent.; P., 0.04 per cent. The metal has now to be carburised and deoxidised. This is done by the addition of the "mix." The composition after the additions should be approximately:—C., 0.23 per cent.; Si., 0.2 to 0.3 per cent.; Mn., 0.4 to 0.5 per cent.; S. and P., 0.04 per cent. The mix is made up from spiegel, silicon-spiegel, and pig-iron, the quantity of each needed being calculated to bring the composition up to the second analysis given.

Summary.

Taking it all round, the difficulties in the way of producing mild-steel castings are great, but much progress has been made in recent years. The manufacture of malleable is a much older business, but the progress made is not what it should be. Speaking broadly, malleable iron as it is produced commercially to-day is not a material that arouses enthusiasm. The tests shown, which have been made in quite an impartial manner, support this view. At the same time there are great possibilities about the metal, but the trade suffers from a spirit of conservatism and secrecy. Looking through the various batches of malleable received, the writer has come to the conclusion that there is a tendency among modern malleable founders to use a higher silicon iron than was used in the earlier days. This may be owing to the difficulty in obtaining irons with low sulphur. The writer does not think, however, that the ideal annealing process required by the new conditions has yet been attained. The rapid decomposition of cementite into pearlite and graphite is not enough to make a good malleable casting, and an endeavour should be made to understand more fully the annealing treatment required for metals of varied composition. With regard to steel, it cannot be denied that we have here a material much superior physically. Notwithstanding its excessive liability to blow-holes, etc., and the many problems that confront the founder of mild-steel castings, the writer is convinced that great developments will take

FIG. 3a.—MICROGRAPH C OF FIG. 3; ETCHED; MAG. × 1,200; REDUCED TO ABOUT 800 IN REPRODUCTION.

FIG. 6a.—MICROGRAPH C OF FIG. 6; ETCHED; MAG. × 1,200; REDUCED TO ABOUT 800 IN REPRODUCTION.

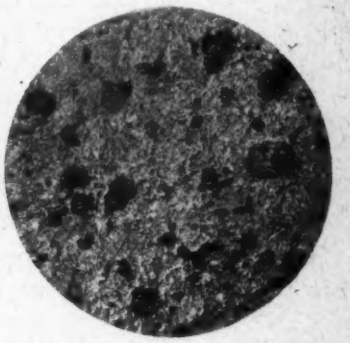


FIG. 9a.—MICROGRAPH B OF FIG. 9.

place in this industry in the immediate future. In this development the electric furnace will play an important part.

Remarks on Micro-photographs.

The author made the following further comments on exhibiting the slides shown in the accompanying illustrations:—

The Shrinkage of Malleable Iron on Casting and Annealing.—Most malleable-iron founders have experienced trouble in cracking and other faults consequent on variable shrinkage, so Fig. 2 may call for some interesting discussion. It will be seen that whilst the shrinkage in the white casting only varies slightly in low and high silicon, the annealing produces a further shrinkage in the low silicon and an expansion in the high-silicon iron. This is of utmost importance, both to the pattern-maker and moulder, and further indicates the necessity of a thorough knowledge of irons in use. Time permitted only the four tests shown, otherwise a few tests done between silicon limits of 0.50 and 0.70 would have determined the neutral zone where no further shrinkage or expansion takes place on annealing.

The Annealing of Steel Castings.—Fig. 14 represents steel as cast, as annealed, and as oil-quenched. The fact that the annealing of steel increases the impact figure from 10 to 30 ft.-lbs. is sufficient proof that annealing considerably improves the quality of the steel. As the question of cost, however, plays a great part in the plans of many a steel founder, it is not safe to dogmatise or suggest that all steel castings should be annealed. The quality of a good steel casting is so good—even as cast—that due consideration must be given to the work such a casting is subjected to, in order that the advantages of annealing may not be counter-balanced by the increased cost of manufacture. Where possible, however, a short annealing treatment to release casting stresses is almost necessary—a muffle treatment of 2 to 6 hours, according to size and section, at 900 deg. C. to 960 deg. C., and cooling slowly in sand or lime will meet this requirement. This treatment, however, must not be confused with annealing proper, as no great alteration to the physical properties must be expected by its use. The main value of annealing is, of course, in the alteration of structure, which produces the alteration in physical properties. On referring to the slide, we would naturally expect the coarse angular ferrite and pearlite shown to be comparatively brittle, whilst the breaking down of this tructure to the more rounded annealed structure indicates a corresponding gain in toughness and ductility. The oil-quenched specimen shows a further breaking down of the extremely fine structure shown. It is advisable, however, where oil-quenching is resorted to, that such treatment be followed by a tempering treatment—the lead bath is the most effective method of performing this operation and 5 hours at a temperature of 550 deg. C., to 570 deg. C. is a suitable treatment.

Fig. 15 shows the increase in hardness (measured by the Brinell machine) of the material as annealed and the same material quenched in water from 850 deg. C. It will be seen that in the first state all the samples are machineable, and whilst varying considerably, that variation is much smaller than that shown in the quenched state. The steels vary according to the carbon content, but no heat treatment would render a 0.15 per cent. C steel unmachineable. The malleable cast-iron specimens are, however, with few exceptions, quite unmachineable after this treatment. Now as certain brazing and other operations approximate to this treatment, it is of value to know which type of malleable is unsuitable for receiving any subsequent heat treatment. On referring to Fig. 15, it may be stated definitely that any cast malleable of high-silicon content in which a large amount of carbon is left in the graphitic and combined forms is quite unsuitable. Even a black-heart malleable containing no combined carbon is hardened considerably after quenching. The most suitable iron for this purpose is a low-silicon, fairly high-sulphur metal in which the annealing is accomplished by a heavy removal of carbon and in which there is a non-hardening ferrite edge, as shown in sample No. 7 (Fig. 10). Sample No. 5 (Fig. 8) indicates that even with a high silicon intelligent annealing will produce this non-hardening ferrite edge, which is so regrettably absent in most of the samples tested. The extreme hardness of these samples unfortunately prevented any analysis being done to indicate the exact change in the amount of combined carbon after quenching, and the time did not allow a microscopic examination. Perhaps some member has experience on this matter, and I shall be glad to hear his views.

FIG. 9*b*.—MICROGRAPH C OF FIG. 9.

FIG. 10*a*.—MICROGRAPH A OF FIG. 10.

FIG. 11*a*.—MICROGRAPH C OF FIG. 11 MAG. × 1,200; REDUCED TO ABOUT 800 IN REPRODUCTION.

Discussion.

The CHAIRMAN, opening the discussion, said American people were claiming superiority over English workers in the production of malleable cast iron. In America the difficulty of producing a sound and satisfactory metal had been recognised, and steps had been taken to form a union specially to consider subjects relating to malleable castings, and he believed that a great deal of progress had been made. A number of tests had been made which

were referred to in a paper given before the American Foundrymen's Association in September, 1915.

MR. J. MATTHEWS asked for some further information with regard to the influence of manganese, which had been frequently mentioned in the course of local discussions.

MR. SHEARMAN, calling attention to the feeders in pattern plates exhibited, asked whether it would be advisable to use all those feeders in casting from a crucible.

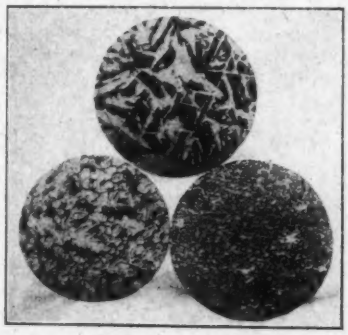


FIG. 14.—EFFECT OF HEAT-TREATMENT ON CAST STEEL. TOP: AS CAST. LEFT: ANNEALED. RIGHT: OIL QUENCHED.

In that case there would be more weight in the feeders than in the actual casting. While that would be an easy matter to overcome with cupola melting, yet with a pot furnace or crucible it might cause more trouble to have so large a quantity of metal in the feeders. He would be glad to know if Mr. Harley had had any experience in snap-flask work for malleable iron. If so, with what success?

MR. R. BUCHANAN said Mr. Harley had taken his courage in both hands and shown his work more fully than had ever before been exhibited by a member. His success in the production of the highest class of malleable casting was well deserved. Obviously, malleable work could not be produced with uniform success without the maintenance of the same careful methods. The malleable trade had suffered from conservatism and secrecy, especially the latter. He remembered nine years ago saying at one of the Foundrymen's Conventions that if the malleable people would tell them about their errors and difficulties they would be quite content if they kept their successes to themselves. The less a man knew about his business the less ready he was to talk about it. That applied especially to the malleable people. Each man was working in his own dark corner, with his back to the light. He was all the while making mistakes, and did not know why he was making them. As to the breaking down of manganese compounds, his (Mr. Buchanan's) idea was that the manganese compound was so difficult to break down that, at the annealing-furnace temperature, the breaking down would involve the spoiling of the casting. The manganese had to be kept low, because at the ordinary temperature they would get hard parts in the casting. Mr. Harley had mentioned the difficulty of the circular furnace in regard to regularity of temperature. His (the speaker's) experience with grey cast iron showed the great importance of a soaking heat to get the work of annealing well done. Mr. Harley had pointed out that in a furnace containing ten or twelve tons of metal he found considerable variations between one part of the furnace and another. One of the most valuable things pointed out was the importance of the relation between the silicon and sulphur contents in the casting, and as they varied in relation to each other so the annealing temperature must be regulated.

MR. F. JOHNSON said he would like to know from Mr. Harley in what way he obtained his samples for analysis. As they were all aware, malleable iron was subject to great variations of composition. While the author appeared generally to appreciate the use of the microscope, he mentioned in one passage in his paper what appeared to be a reflection on its value, and that was in reference to the structure of the pearlite in one of the specimens. In that case it was clear that though the structure was very beautiful the properties of the metal were not satisfactory. He believed that was very often true, as shown by metallography, not only of iron and steel, but of other metals and alloys. In fact, it seemed to be commonly the case that beautiful structures were structures to be avoided because they were usually brittle, and therefore indicated useless metals or alloys. It was not the beautiful structure they looked for, but the structure which one usually associated with sound and reliable metal and good physical and mechanical properties. He would like Mr. Harley to state that he had really found the microscope useful. On most of the slides the author had shown two test-bars, one thin and one thick. Apparently in some instances they had been subjected to different treatment, and that vitiated comparisons.

MR. A. HARLEY, replying to the discussion, took the opportunity of acknowledging the valuable help given by Mr. Toplis, one of his assistants, in the preparation of the micro-photographs. The Chairman had referred to electrical steel. Personally, he had no experience of electrical furnaces, although he had seen several types at work. Theoretically, he was very optimistic about the quality of steel which he thought it was possible to produce from an electric furnace. The extra heat available would produce steel of greater fluidity, and the metal therefore would be much cleaner and freer from gas. The

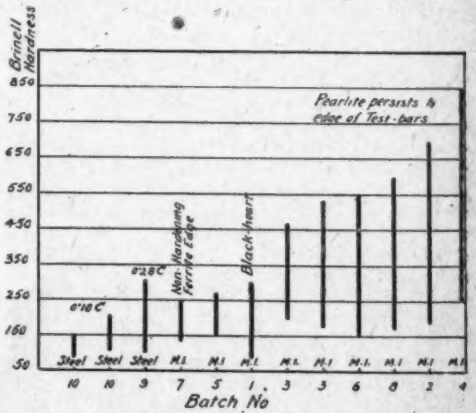


FIG. 15.—GRAPHIC REPRESENTATION OF INCREASE IN HARDNESS PRODUCED BY QUENCHING FROM 820° C.

slag which existed in the metal in a finely divided state would be allowed to rise and float on the top. He believed that in a properly designed electric furnace steel could be melted in such a manner as to greatly improve the physical qualities. Even for special work in cast iron and bronze, where the cost factor was not all-important, such a furnace would be very advantageous. With regard

to Mr. Shearman's question as to whether the feeders required to be as large in crucible-melted metal, he was inclined to think not, as crucible-melted iron was generally lower in silicon than cupola-melted metal. Further, there was a tendency among those who used cupola-melted metal to be somewhat more generous in the size of feeders. Crucible-melted metal being more expensive, greater care would be exercised in this and other respects. This point raised an interesting speculation regarding the use of chills and feeders. It might be found that the advocates of chills were generally men who were handling crucible-melted metal, and therefore the use of feeders was strictly limited. The men who favoured the use of feeders instead of chills were probably those who were using cupola-melted metal where, owing to the lower melting cost, greater freedom in this respect was allowed. With regard to snap-flask work, that system did not commend itself for the class of work he produced. In this work they had to operate within very fine limits, so that they had preferred to go in for box plant carefully and accurately made. This expenditure was justified where great accuracy was essential, and particularly where skilled labour was not available. He quite agreed with Mr. Buchanan that the man who was suspiciously secretive had a limited horizon, and often enough had very little to impart. It was only by an increase of knowledge that the foundry trade in any section could come into line with the best engineering practice, and it was only by applying exact methods that real progress could be made. With regard to the use of pyrometers, he had found that the position of the pyrometer with regard to the flame greatly affected the reading, and in such circumstances was not a correct index of the temperature throughout the oven. He believed in pyrometers, as he believed in all instruments that ensured accuracy. Pyrometers, however, were apt to get out of order, and he had found it necessary to adopt a method of checking which had given very satisfactory results. This was by inserting a small and definite quantity of silver. The melting point of silver was 960 deg. C., and fairly accurate and useful data could be established between this temperature and 980 deg. C. based on the time taken to melt. When a pyrometer was inserted in an annealing oven there was a tendency on the part of the men to trust to the pyrometer implicitly, and to neglect acquiring experience in judging temperatures by the eye, so that when the pyrometer did go wrong this fact would be discovered before serious damage occurred. With regard to the proper annealing temperature, there was no secret about that. Every worker had to discover the temperature suitable to his particular class of work. That was why speakers were usually very loth to state definitely a particular temperature. One man might be producing low-grade work with high silicon content, where a temperature of 900 to 940 degrees might be ample. Another would be making high-class work with fairly low silicon, where a high temperature and hard anneal was essential. For this class of work a temperature of 960 to 980 degrees was required. The temperature to be obtained was not by any means exclusively important, the time factor was equally important. In his experience also "soaking" was advisable. The value of "soaking" was explained by the fact that if the elimination of carbon was proceeding too vigorously the oven was given time to adjust itself by enabling the diffusion of carbon to proceed towards the edge or skin of the casting. If this was not done "peeling" would result owing to the oxidation of the ferrite. There was no doubt that carbon was eliminated while in the combined state. After actual precipitation it was more difficult to eliminate. In reply to Mr. Johnson's question regarding the method of sampling for analysis, he rather anticipated an inquiry on this point, and would read one of the notes which, for want of time, could not be introduced into the paper: —"Analyses.—In malleable iron the amount of carbon in the metal varies according to the distance from the centre, so a hole was drilled completely through the bars, and after intimately mixing the drillings the same were taken for analyses. The silicon, sulphur, phosphorus and manganese are all constant, and therefore the analyses given are representative of the pig-iron mixture used. Microscopic analysis is needed to supplement the chemical analysis in orde to find out the distribution of carbon throughout th sample. Of course, a series of analyses taken on suc cessive layers will give this information, but as a few minutes at the microscope save perhaps a day's labour in the laboratory the advantage is obvious."

Apparently his remark about the value of micro-photographs was misunderstood. He took it that in good malleable iron there should be in the interior a well-developed laminated pearlite, and that was shown up in the particular photograph referred to, although the general quality of malleable as shown by the physical tests was poor. What he meant to say was that photographs of such high magnification, namely, 1,200 diameters, might be misleading to generalise from, as the area of the structure shown up was so exceedingly small. He hardly thought it was necessary to affirm the great value of microscopic analysis, not only in research work, but also in the ordinary routine work of the foundry. Another point made by Mr. Johnson was as to the difference in the treatment of the thin bar and the thick bar. Here again, perhaps, he had not made himself quite clear. In the batches of malleable the top line of physical results shown referred to the thick bar, the lower line to the physical tests made on the thin bar. In the samples of steel shown, the top line gave the physical test for the thick bar as cast, and the lower line for the thick bar as annealed. The sample of steel referred to was specially annealed to ascertain the maximum elongation and contraction possible. Reverting to the malleable specimens shown, the 1-in. bar was not expected to give a very large bend, but the comparison with cast steel of the same section was interesting. Even in the ½-in. bars the bends shown were, generally speaking, disappointing. Although this section differed from the Government specification, the bend test should have been more favourable with the ½-in. bar. The Admiralty specified that a bar 1 in. by ⅜ in. should bend round a 1-in. radius at least 90 deg. without showing sign of fracture. A simple calculation would show that the comparative stiffness of the Government bar to the ½-in. bar was as 25 to 14. He did not set out to criticise malleable cast-iron as a material, he was merely after the facts. In producing large quantities of both malleable and steel castings certain comparisons were inevitable. He had already stated that there were great possibilities about the metal. The tests shown, however, on these representative samples proved that in the majority of cases these possibilities were not being realised, and that further research was required as well as a more intelligent application of the knowledge already available.

A hearty vote of thanks was accorded the author for his paper.

Hard Solder.—A hard solder of low fusing-point, used by a large electrical company, is composed of:—Copper, 34.36 per cent.; silver, 49.24 per cent.; zinc, 16.40 per cent. Borax is used as a flux.

Core Binders.

Before a recent meeting of the Birmingham Branch of the British Foundrymen's Association a discussion took place on core binders. Mr. D. Dalrymple occupied the chair. Mr. J. G. Robinson (Halifax) opened the discussion and illustrated his remarks by a number of sample cores. A summary of his comments is as follows:

Comparatively few years have passed since cores were made entirely of new moulding sand. The introduction of new kinds of binders and sand-mixing machinery in recent years has brought about a condition in some shops whereby all the core sand may be used over again indefinitely with only sufficient new sand added to make good the waste. The main object in all these introductions and improvements has not been to enable the moulder to make good, clean, sound castings, because we have proof that for hundreds of years castings have been produced of very high quality, at a cost; so that although the quality of the castings may have been improved in addition, the main object has been the reduction of cost in the finished article.

No matter how enthusiastic we may be in producing castings of which we may justifiably be proud, we must get the £ s. d. notion firmly planted in our minds; consequently in solving any core-binder problem, the ultimate cost is the guiding factor. To determine this the main points to be considered are: (1) The strength of the core mixture, both green and dry. (2) The character of the surface which the core presents to the metal. (3) The percentage of vent area in the core. (4) The ability of the core to resist moisture. (5) The ease with which the core can be cleaned from the casting. (6) The character of the fumes given off during baking and pouring the mould. (7) The number of cores a man can make in a day from a given mixture. (8) Cost of drying.

As to the general characteristics of the different classes of binders, in foundry practice a sand binder is that agent which holds the grains of sand in the body of a mould or core in place when the metal is introduced into the mould. In the October issue of THE FOUNDRY TRADE JOURNAL was published a paper by H. M. Lane, who classifies them as follows: (1) Colloids and allied bodies, which include clay and horse manure. (2) Water-soluble binders, which include molasses, sour beer, glutrin and glue. (3) Paste binders, flour, starch and dextrine. (4) Gums, resin and pitch. (5) Oils.

The use of clay-bonded sands is too well known to need explanation, but it is necessary to mention it on account of the action of the other binders in conjunction with it.

Dealing with the water-soluble binders, the action of molasses is rather uncertain, owing to the variation in the way in which the sugar canes are topped. Molasses also is subject to fermentation, and this changes its adhesive powers. During baking molasses have a tendency to boil, and this may deform the core. If the cores are taken from the oven at the critical point it will be found serviceable, but if the cores are taken out too soon it will not have developed sufficient strength to give a strong core, and if left a little too long the strength falls off.

Glutrin is uniform in composition and hence in binding power, and will not ferment. The compounds contained in glutrin are of such a nature that they do not enter into and combine with clay as does oil, but they do form with it an exceedingly efficient emulsion and tend to carry it from the faces of the sand grains to the points of contact. In drying, glutrin behaves more like oil, in that it tends to flow to the contact points. The fact that glutrin lacks the viscosity of linseed oil gives it in sharp sand a tendency to follow the moisture to the surface of the core. In a mixture of clean sharp sand, glutrin will tend to give a very hard skin and a soft interior. The glutrin tends to sweat to the surface of the core, giving a hard surface, and even though the main body of the core may be fairly well bound, the dense layer on the outer surfaces interferes with the escape of the steam from the interior towards the latter part of the drying operations, and may result in an imperfectly dried core. The sweating tendency is overcome by the addition of 1 per cent. of clay into the mixture, the clay and the glutrin together forming a compound which is sufficiently viscous, so that it draws to the contact points rather than follows the moisture to the surface of the core, thus making it strong and at the same time making it one which does not have the vent passages stopped. Glutrin can be used with oil mixtures, as the oil prevents it from sweating to the surface of the core and the combination blends well.

[The speaker then proceeded to discuss various other binders, the properties of which are detailed in Mr. Lane's article above referred to.]

We now come to the oil binders. All the other binders mentioned give best results when used with clay-bonded sands. When using bondless sands, oil is best. The action of oil in bonding a core is as follows: The material

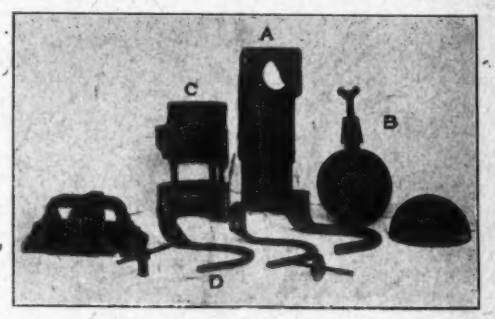


FIG. 1.

must be thoroughly mixed with the sand so that every grain is covered with oil or an emulsion of oil and water. When the heat of the core oven acts on the sand the moisture is evaporated and driven off. As the moisture passes through the core towards the outside, the oil remains behind, and first uniformly coats each grain of sand and finally dries down and forms an area of bond somewhat larger than the contact points. The binding power is developed by the oxidation of the oil just as a paint film dries by oxidation. Paint chemists have found that the addition of certain oxides hastens the drying. The reason is these oxides take oxygen from the air and in turn transfer it to the oil and cause the oil to oxidise more rapidly; consequently a good supply of oxygen is necessary to obtain the best baking results.

First, the strength of the green mixture is of importance in cases where cores must stand at a considerable height above the plate during drying, and if the core has any overhanging bodies it must possess sufficient green strength to carry these. The strength of the resulting core is governed by the amount of pressure which must exist as the metal enters the mould and the amount of handling required. With clay-bonded

sand and suitable binders the green strength is afforded by the use of irons and ramming, and the addition of artificial binders suitable for that sand supplies the strength for the dried core and reduces the number of irons required. With bondless sand and oil binders, flour and dextrine will supply the green strength and not seriously weaken the resulting core, but will absorb oil and reduce the vent.

Another method we adopt is to place oil-sand next to the faces of the core box and ram the inside with ordinary core sand similar to the cylinder core shown in Fig. 1 (A). In the dried core the strength supplied by the oil binder is such that it will resist almost any pressure of metal and any amount of handling. Few irons are required and practically no ramming; consequently the cores are made in less time. The diagram Fig. 2 shows the relative strengths of a number of binders.

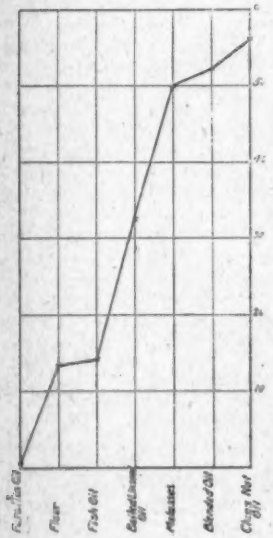


FIG. 2.

Under the heading of core surface must be considered the character of the surface presented to the metal, its ability to carry off the air and gases displaced by the metal, and the freedom with which the burnt core separates from the surface of the interior of the casting. It is necessary to use a mixture which will present a close uniform texture, the voids or spaces of which are so fine that the metal cannot flow into them. In some cases it is necessary to black the face of the core to partially close the space and make the core clean out more readily. Too much clay, flour and similar binders gives a hard surface, on which the metal will not lie and the air cannot strike through. With oil-sand the surface is always porous and it can be blacked as can other mixtures to ensure a clean face on the casting. Also, if any dressing of the core is required, this can easily be done by rubbing with an emery stone and a good face on the core still retained.

With regard to the percentage of vent area, there must be considered the size of sand grains and their character, also the character of the bond and the extent to which it blocks the vent. In cores it is desirable to have the greatest possible number of fine voids, only they should be so fine that the metal will not tend to follow or flow into them. In cases of cores which are to be entirely surrounded by metal with the exception of a small print, the sand mixtures must have a maximum amount of vent. Under this heading, an oil binder is preferable to any other. A coarser sand can be used, and, as previously explained, its particular action during drying is such that it does not fill the voids; consequently a larger percentage of vent area is obtained by its use than by the use of any other class of binder. The sample cores for a 9 in. diameter bomb head (Fig. 1 B), and for a water-jacketed marine cylinder (Fig. 1 C) illustrate what is meant by cores entirely covered with metal, except for a small print.

In connection with resistance to moisture must be considered the length of time the cores remain in the mould and the manner of handling and storing them. If high-grade oil-sand cores are used, their moisture-resisting properties are such that no ill effects need be feared from leaving them in the mould, or in connection with their storing, but other binders show a tendency to absorb moisture, and have to be used accordingly.

Oil-sand cores have an advantage possessed by few other binders in that a core made from clean sand and oil has no tendency to absorb moisture and can be kept without losing strength for an indefinite length of time. We have at our works two sets of cylinder cores which were made over five years ago. They are still as good as new.

The ease of cleaning a core from a casting is one of the important problems in the expense of making castings. A proper core should rattle out without any difficulty, leaving a good smooth interior surface. In the case of brass or bronze castings they are largely blown out by dipping the hot castings into water, the steam thus formed blowing out the core. Iron castings cannot be so treated and therefore the core must be compounded and baked so as to clean freely. With binders requiring a clay-bonded sand the cores have a tendency to bake hard in the casting and entail much labour in fettling.

In the case of oil we start with a sand possessing no bond. The bond is supplied by the oil. During casting the oil is burnt out and the bond destroyed, so that a tap with a hammer is usually sufficient to clear the core from the casting. The bomb and the jacket core, also the small bend pipe core (Fig. 1 D) will serve to illustrate, even to a non-practical man, that a core of this description will save much expense in fettling. At our own works the use of oil-sand saves at least 50 per cent. of fettling expenses.

When we come to consider the character of the fumes given off, both in the core shop and in the foundry during casting, the advantage is certainly not with oil binders. Certain oil mixtures give off very disagreeable odours even when the sand is being worked by the core makers and much worse when the cores are withdrawn from the stove, and again when the moulds are being cast. Seeing that less offensive mixtures which are equally efficient can be procured, it is only fair to the workman to use them, and if this point were more seriously considered by employers a tremendous lot of prejudice against oil-sand would be abolished. Then, again, at casting time, if the gases are lighted as they come from the vents, most of the disagreeable odours can be destroyed.

With regard to the number of cores which can be made in a given time, this depends largely on the shape of the core and the number of cores required. In a large number of cases, the fact of simply being able to bed the sand in the box without the use of irons when using oil-sand increases the output, whereas with gum binders the sand sticks to the box, and with clay-bonded sands ramming is necessary. Really the preparation of tackle is the determining factor in production, so that if an oil-sand core is the most suitable for the work in hand and the number of cores required warrants the expense, then make the tackle accordingly.

As to the cost of drying, the length of time it takes to dry each different class of core when using different binders determines the capacity of the core ovens, their fuel consumption and the space which must be devoted to equipment of this kind. Quick-drying core mixtures increase this capacity and so decrease the plant expense.

Oil-sand cores take longer to dry than most cores with other binders, but usually cores are prepared overnight, particularly if they are of any size, and where an ordinary sand core will dry in the night most oil-sand cores will do likewise. This, of course, is dependent on the stove arrangements. To secure the best results for drying

oil-sand, as previously explained, a supply of oxygen is necessary. This means that a stove after firing must not simply be shut up to keep the heat in, but must have a certain amount of draught. When small cores are required in a hurry we find that the addition of a small amount of core gum to the mixed oil-sand we use hastens the drying very considerably.

Summing up these considerations, I think we can safely say that for cores where the shape lends itself to the use of oil-sand, and for such cores as water-jacket spaces where venting and fettling are a big consideration; for cores where the outlet for vent is very limited; for cores that require much handling, and for cores that have to be left in such a position as to be liable to absorb moisture, an oil binder is preferable to any other artificial binder.

Also, when one considers the amount of coring which can now be done to save drilling and machining; the factor of safety with regard to venting, which means a higher percentage of good castings; and the saving of labour in core-making and fettling, all tending to increase the output, I think we cannot but admit that after paying for the binder there is a final saving.

With regard to mixing oil and sand, the main thing is to get the proper proportions of materials and see that they are thoroughly mixed. I know that some very ingenious and effective contrivances for this purpose have been introduced, by which the oil and water are emulsified before mixing with the sand, and this undoubtedly is the best method, as it increases the efficiency of the oil by better distribution, consequently reducing the amount of oil required and effecting a saving accordingly. However, as there are many who do not possess a machine, but have to use a shovel and riddle, I may say the proportions usually recommended of one of oil to forty of sand should give a core strong enough for anything. To this must be added sufficient moisture for working. Mr. Cook has stated that he used six parts water to one of oil, but I find seven to eight parts of water work better. At one time I thought we got best results by mixing the sand as it was delivered, adding what quantity of water we thought necessary and then adding the oil. It certainly was the easiest but not the best, as I found out by experiments.

The sample pieces of cores were all mixed in exactly the same proportions, one of oil, eight of water, forty-eight dry sand, but in one case the oil and sand were mixed and the water was added afterwards, and in the other case the water and sand were mixed first and the oil added afterwards. The one with the oil mixed with the dry sand was the much better core. Thorough mixing is absolutely essential, but grinding is not beneficial, in fact the reverse in oil-sand mixtures, although with a bonded sand and suitable binders it is an improvement. It is best to mix the sand as required and not in big batches.

It is necessary to allow one-eighth of an inch in nine inches for sinking of the core during handling green and drying. For instance, in the 9-in. diameter bomb core the half boxes were machined out to true half spheres, and we had to pin ⅛ in. plate on one joint to get a true sphere.

Before turning the cores out of the boxes on to the plates for drying, paper should be placed between the core and plate to prevent sticking. When using dishes or cast-iron boxes and drying the core in place, it is a good practice to coat them with a mixture of one part of paraffin to three parts of spermoline and give them a night in the stove, repeating the operation the following night, after which the cores will leave the box easily when baked. Do not dry in a slow stove; about 450° to 500° F. is the best heat.

Discussion.

THE PRESIDENT, who also exhibited a number of sample cores, said that some time ago he came to the conclusion that there was nothing so good as spermoline for small cores, at any rate for cores similar to the samples exhibited. He also found that spermoline was very good for putting on certain parts of the moulds, such as sharp projections, to prevent the washing away of the sand when casting. But latterly he had taken to using binderit, which he considered to be one of the best binders. It was very simple to use and had no obnoxious smell, and was also very economical. He had used it now for over two years in small intricate cores, and, as a rule, no wires or sprigs of any kind were required. The cores he was showing were most of them made with five parts of red sand and four parts of old sand. Four pounds of binderit were boiled down with one gallon of water, and this liquid was spread over six barrows of sand, say eight cwt. The sand was not ground, it was only mixed. Of the cores shown by him, there was only one that had any sprigs in it at all; it had a wire in it and it was hardly possible to use a core of that description without a wire of some kind. Some of the cores shown were made as far back as the beginning of October, and they had the same binding qualities as the others which were made that morning. To make the mixture a little bit stronger, seven pounds of binderit were used with the same quantity of sand. The cores had a tendency to lose part of their qualities by exposure to the air, but after being put into the stove for a couple of minutes they recovered all their qualities again. Of all the binders he had used, he had never found any other so well suited for that class of core. The cores came away from the recesses in the castings very freely when fettling. The work was done mostly by girls, and they turned out anything up to 3,000 cores a day, and there was no trouble at all with breakages.

Mr. J. SHAW said that in his own foundry they did not often use oil cores except in repetition work. Mr. Robinson might have mentioned that oil with ordinary bonded sand was not very beneficial. The clay in ordinary sand absorbed the oil, and though the oil did strengthen the core to some extent, it did not give the same strength as with a sharp sand, such as sea sand. One good test of oils was the iodine test, such as painters used; it gave a very fair index as to the binding quality of the oil. As to the comparative efficiencies of the different core binders on the market, most of the flour compositions were liable to take up moisture, and, therefore, were not good where cores had to be stocked or even where a job had to be left overnight. He would like to ask what was the largest-sized core Mr. Robinson had ever made with oil binders. He believed, from conversations he had had with different people, that makers of core binders could blend the oil to suit the temperature of the particular oven in which the cores were baked. It was possible in certain cases to use burnt sand as a sharp sand for cores instead of introducing a sea sand. With large cores made on collapsible barrels covered with ⅛ in. loam, the burnt sand was found to be a very good substitute for the sharp sand.

Mr. H. MATHER said that his works had a sand hill of their own and had to use it. It was like a building sand, and to utilise it he had to introduce core gum as a binder. He would like Mr. Robinson to say what he thought of the use of oil with this building sand. It was another case of £ s. d.; they had the sand and were expected to use it as far as they could, but in some special cases they had to buy new sand at 5s. 6d. or 6s. a ton. They had been told by Mr. Robinson that by making cores in oil-sand they could be made at a cheaper rate. He took it that the core-boxes, etc., for all these things

would be a big item in the pattern-making account, as Mr. Robinson appeared to use iron boxes and special plates for the oil-sand cores.

Mr. J. STERLAND could not understand why vents should be put in cores made with oil-sand, for he found that the air and vapour escaped sufficiently without vents if the tops of the cores were scraped. At Coventry they had made cores 2 feet or 3 feet square, and very thin in some places, and had not found it necessary to put any vents in them. He was speaking of cores made with spermoline. They also used an emulsion of one part of oil to five parts of water, and to this was added seven to nine parts of sand.

Mr. F. E. SHEARMAN wished to know whether Mr. Robinson found it beneficial to mix the sand at night and use it next morning, or whether it was better to use it immediately after mixing with the oil and water. He congratulated Mr. Robinson upon his success in making the bomb core. Many firms had had a great deal of trouble in making a success of that bomb. How did Mr. Robinson fasten the two halves of the core together? Some time ago he saw a very good method. The core was made very much in the same way, but in the bottom half there was a small cast-iron grid in the centre of which was a little hole. Through that hole was passed a pin which held the grid to the tube from the top and this kept the lower half in place.

Mr. ROBINSON, in reply, said that all the binders mentioned previous to the oil binders were suitable to a clay-bonded sand, and the oil binders to a bondless sand. When clay was present it absorbed a great deal of the oil before the oil began to work, and only after sufficient oil had been absorbed to neutralise the effect of the clay did the binding effect of the oil begin to be realised, so that in using oil with clay it was to a large extent wasted. This was easily demonstrated in cases where large cores had their vents carried through the top part of the mould, and it was necessary to make good round the vent hole. He did this by placing soft loam round the hole, and when the top part was lowered on it squeezed the loam and made a safe joint so that the metal could not enter the vents. If the cores were warm, and just ordinary loam was used, it baked hard and was liable to cause a crush. To prevent this, oil was mixed with the loam before using, and it remained soft and did not crush. That alone showed that the effect of the oil was to neutralise the clay. For the "sausage" machine, or rotary core machine, the mixtures he used were as follows:—

For cores 3 in. to 5 in. diameter: 6 gallons of core sand; 3 gallons of sea sand; 1 pint of core gum; 1½ lbs. of flour; 4 pints of oil; ground for three minutes, then riddled through ¼ in. mesh.

For cores up to 2½ in.: 3 gallons of sea sand; 3 quarts of core sand; 10 oz. of flour; 7 oz. of core gum; 2 pints of oil; riddled through ¼ in. mesh, *not* ground.

Ordinary core sand, as used above: 5 parts new, 20 old, 1 horse-dung.

The largest castings he had made with oil-sand cores were for water-jacketed cylinders, the cylinder itself weighing two tons. It did not matter what the size of the core was; if he wanted an oil sand face next to the casting, to allow for contraction he packed up all round inside with ordinary core sand. He had made cores that were 6 feet long and would have no hesitation in using oil-sand for any size of core. The thickness of the jacket core was 2 nches. He made some water-jackets cast in one piece 14 feet long and the water space was 1½ inches. With regard to the question of using oil blended to suit the heat of the core stove, that depended upon the composition of the oil. The flash point of linseed oil was 550 deg. Fahr., and the carbonising point 750 deg., whilst spermoline had a flash point of 230 deg., so that in the latter case the volatile matter would be driven off much more quickly than it would be with pure linseed oil. In order to prevent the burning of cores which happened to be put at the top of the stove or of parts which dried more quickly than did others, they sprinkled oil over them with an oil-can before putting them into the oven. As to using burnt sand in place of sea sand, they had used the burnt or spent sea sand from the oil-sand cores, but had not obtained particularly good results; they got too much dust and this absorbed the oil. The dust also tended to clog the vents.

With regard to ordinary building sand, continued the speaker, that contained a certain amount of clay, though not a great deal. One could not get such good results with it as with sea sand, but it might be used for an oil mixture. As to the expense of making oil-sand cores, no special boxes were required; any ordinary box could be used, and although he mentioned cast-iron boxes, that was only for what was absolutely repetition work. As to the question, "Why put vents in when the air will come away without?" he was a firm believer in the saying that "a vent hole is never missed." And whenever he could put one in he put it in. He had not the least doubt that the core in question would vent itself, but it took very little trouble to make sure. With regard to the proportion of oil to sand mentioned by one of the speakers, he would say that he himself did not always use the same proportion of oil; if the core was good enough for its purpose with one to fifty they did not use one to forty. As to mixing the sand overnight, he would repeat the advice not to mix it in big lots; it was far better to mix the sand as near as possible to the time of using. If it were mixed overnight there would be a tendency for the oil to drain to the bottom, so that the sand at the top would not have sufficient. Again, the atmosphere had a tendency to dry the sand, and then one got a "nesh"—a core that was not strong enough to stand by itself.

FIG. 3.

Mr. ROBINSON concluded: We have been very successful at our works with the bomb casting, and it may be beneficial to some to describe the methods we have adopted. The shape of the casting lends itself to easy moulding by making a joint along the centre line in either direction, *i.e.*, along the vertical or horizontal axis. Some founders have made their patterns to mould two together in the shape of a "dumb bell," the core being

supported on a print or seating between the two. We make them singly with the joint along the other axis, having the socket in the bottom and the outlet in the top, as Fig. 3, which shows the two half patterns on plates. The socket on the bottom half pattern is made as though it were to leave its

FIG. 4.

own core in the mould. We make a separate core for this and place it in the pattern before commencing ramming the sand. On the top half of the pattern the core print at the largest point corresponds with the diameter of the facing on the finished casting, 2½ in. This print is 3½ in. long and tapers to 1¾ in. diameter. On this print extending the whole length three flats are filed. Their use will be explained later. The main core is made in halves and jointed, the bottom half being a plain half sphere. The core box for this is made of aluminium, which makes it light for handling. (Fig. 4.) Oil-sand is placed round the inside of the box about ¼ in. thick, and the inside filled with ashes with a thin layer of oil-sand along the face of the joint. Paper is laid on the joint, the plate for carrying and drying fixed, the whole turned over and the box lifted off. The top-half core box, in addition to forming half a sphere, also forms a part to match the print on the pattern, except that it is perfectly round where there are flats on the pattern. It also forms the 1¾ in. diameter hole in the top of the bomb and the facing round same by means of the loose half rings as shown in Fig. 4.

The box is mounted on a rock-over moulding machine for ease and accuracy in drawing the box from the core. The method of supporting this core in the mould is by means of a half-inch tube which is rammed up in the core. In addition to supporting the core it acts as a vent pipe. In the bottom of the core box there is a hole to match the tube in diameter and the depth to suit the distance the tube is required to project through the moulding box when fixing the core in position. This tube is placed in the box, Fig. 4, and oil-sand rammed round it and faced up the sides of the box, the centre being filled with ashes as in the bottom half, paper and plate placed on the joint, the whole turned over on the machine and the box drawn off as shown in Fig. 4. This view also shows the small core and box for the socket end.

The core is made of oil-sand with a "densener" in the centre, which prevents a spongy place at the bottom of the socket, a condition which has given much trouble to makers of these bombs. After drying the main half cores are jointed with core gum, a true sphere being ensured by trying each one with a half round templet as shown in Fig. 4. The cores are all blacked ready for placing in the mould. In commencing moulding the small core is placed in the socket of the bottom half pattern, the box placed on the plate, rammed up, turned over in the place where it will be cast, and pattern drawn.

The top half is rammed up in similar manner. After the pattern is drawn, two ⅜-in. diameter risers are pushed through with a tube and the moulding box lifted on to the stand, as Fig. 3, with the joint upwards. The main core is placed in position in the print. The tube projects through a bar in the top of the box. A washer and thumb-screw are fixed on the tube, by which means the core is screwed down tight in its place. A half-round templet is tried over the core to show when it is in correct position. This is where the effect of the flats on the print is shown.

The core being round, and the seating having flat places, the core is prevented from bedding down until sufficient pressure has been applied by the thumb-screw to squeeze

FIG. 5.

the flats back to the shape of the core. This allows a little adjustment in the thickness of the walls of the casting which can be seen on the joint. Usually the templet stands up from the joint ¼ in., and by the time the core is screwed down into position it is so firm that it does not move in turning the box over and pouring the mould. The top box is placed on the bottom, loose pins being used for guides, cramps wedged on, pins removed, runner and riser bushes fixed, and the mould is ready for pouring, as Fig. 3.

Castings with High Silicon.—When a high-silicon content, such as 10 to 12 per cent., is required in castings, the metal is best melted in an air furnace, though it can be run down in the cupola. With the air furnace an ordinary metal should be first melted, and when a good heat has been attained, the required ferro-silicon to get the desired content should be added. Some oxidation will occur and reduce the actual quantity of silicon. The bath should be rabbled well before tapping to insure uniformity. If the cupola is used, the safest way is to keep the bed high enough to bring the first iron at the spout in about 15 minutes, in order to avoid oxidising it. The ferro-silicon should be in large lumps,

Prevention of Shots and Cavities in Iron Castings.

By J. Peers.

The castings that are mostly affected by shots and buttons invariably come under the heavy intricate class of work, such as cylinders, cylinder ends, etc., although it is possible for the chemist to find an occasional shot in a casting of thin section by reason of its having got down a runner through the splashing of metal on the foundry floor, which may happen in any shop when moulds are practically at floor level. Heavy work is more susceptible to shots and buttons by reason of the moulds having a greater area of runner space and the way the runners are formed. The writer will endeavour to show how all these defects are obtained, and how they can be avoided.

In the first place gas cavities are found in large castings without shots, with a eutectic having formed in the cavity, which is both puzzling to the chemist and foundry foreman. This very often causes a change to be made in the mixture of the metal, and often worse results follow. In the second place shots are found which have given off gases, and they are also found firmly imbedded in the mass.

There are many that hold an idea that some or most of the shots are formed in the ladle, by reason of the metal splashing from the cupola spout; this is pure fallacy, for any shot formed by tapping is readily melted up again in the ladle when the metal is anything like hot. For example, one often sees moulders put bits of scrap in the metal when too hot for their job and they soon become molten.

Gas cavities are formed without shots by using bottom runners alone. Shots and buttons are formed with or without gas cavities by the use of top gates only. It must be borne in mind that the writer is speaking strictly on the metal, and is not referring to blowholes from a damp mould, it being taken for granted that the mould has been made properly. Each of these methods of gating have good points; one foreman will use bottom gates only with increased runner area to get a good face on the castings and prevent the cutting action of the metal when passing through the mould; another foreman will advocate top gates only, because it allows of the liquid shrinkage to proceed properly, if the thickest section is cast uppermost.

Taking, for example, the case of gas cavities formed without shots. When pouring a cylinder of any size, or work of a like description, with a bottom runner or runners (*a*, Fig. 1), before the metal reaches the top face of the mould the metal becomes sluggish, and moulders are aware it often takes all one's time to force a road through the riser with the feeding rod. Here, then, it will be seen that the occluded gases can only escape in close proximity to the risers, the gases farthest away having no chance of escaping, the metal forming an outer wall and solidifying instantly it touches the face of the mould. If, on the other hand, only top gates were used on the same job (*b*, Fig. 1), this would give the gases a chance of escaping more freely, as the metal being hotter the outer wall would not form so quickly. By this method of top gates the buttons and shots are formed by the sudden drop of metal on the bottom face of mould, similar to dropping metal on to the shop floor out of the ladle, and sometimes in the passage through the mould they become attached to the side of the mould, and becoming covered by a black film of oxide may not properly amalgamate with the metal. At the best it forms unseemly marks, and this is made more serious if an inferior blacking is used. Also pieces off cores may be washed away, and this sand from the fractured part of the core is bound to form a cavity. In high-class work very little causes a waster; therefore it pays to have a knowledge of the job and how to run it. All these facts point to the advisability of combining the two methods, one to get good liquid shrinkage and freer escape of gases, the other to prevent shots and buttons.

Moulding boxes are used with spaces to allow for risers and runners according to the amount required, and it is very important that the top gates should be distributed as evenly as possible, both as regards position and area. The patterns are usually in halves, and a bar should be rammed up in the drag part of the box, one end just projecting out of the space in the box, and the other end beyond where the in-gate is cut into the mould; this allows the first rush of dirt being carried past the

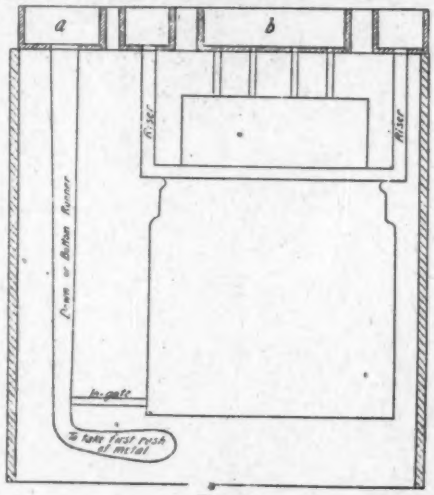


FIG. 1.

in-gate, for in all cases the first rush of metal carries a certain amount of loose dirt which is forced into the mould if this practice is not adhered to (see *a*, Fig. 1).

The top gates are formed round the barrel core, five, six or more, according to size of job, to evenly distribute the metal, preventing any weakness, as usually found where projections or brackets are formed on the casting.

The writer always advocates this class of work being cast vertically, and a pit should be made so that the boxes may be dropped in for casting purposes, thus saving the costly job of digging deep holes, and also facilitating easy access to make up the riser and runner boxes. The best way to pour the mould is by two ladles, about one-third of the metal required for the job being in the ladle for the bottom runner, which, when starting, should be poured somewhat before the other. This forms a good cushion for the metal poured in from the top, preventing the washing away of cores, the formation of shots, gas cavities, and buttons, and allowing a good liquid shrinkage.

It is good policy to make up risers separate from runners if possible and leave them open in dry sand. It is possible to cast the same job by using only one ladle, but plugs have to be resorted to and all runners are in one runner basin.

New Method of Making Basic Converter Bottoms.*

The dolomite—containing about 50 per cent. of fine meal, the rest being granules up to 3 mm. in diameter—is mixed with 10 per cent. of tar in an edge-runner mill until it balls, enough additional tar being then worked in to make the mass flow gradually. This mass is run into the mould, in which the tuyeres have already been erected (the mouths being stopped with clay and topped with conical castings, 6 inches high), until the tuyeres are covered to a depth of about 4 in. A cast-iron cover having been laid on the castings, the mass is dried in an ordinary stove by raising the temperature gradually to 350 deg. C. in 24 hours, and then for another 16–30 hours at 370–400 deg. C., being afterwards left to cool down for two days, by which time it will be ready for use.

The procedure is much the same in making needle bottoms, except that the needle mandrels are of wood, and are kept in position by fitting a perforated plate over the tips. They must also be fired, to char the mandrels, which must be done quickly, the mass being left to burn itself out in the draft of the chimney. With both types of bottom the temperatures should be controlled by a pyrometer connected with a recording device. When properly baked, the mass settles down uniformly, the surplus tar collecting on the surface, whilst the dolomite sinks, so that the tops of the tuyeres are 1 to 2½ in. lower than the surrounding dolomite and are thus protected against cracking off in the converter. To guard against the dislodging of the mass (when rich in tar or imperfectly made) by the pressure of the blast in the tuyeres, the latter may be inserted from below through the bottom plate and flared at the base to fit into countersunk recesses in the plate, which then takes up the blast pressure.

In the following calculation of the cost of making these bottoms, the cost of the calcined dolomite has been taken at 18s. per metric ton, tar at 45s., magnesite tuyeres at £9 10s., coke at 22s., coal at 15s., and wooden mandrels at 32s. per 1,000. On this basis, a needle bottom 68 in. across and 34 in. deep costs £4 10s. for dolomite (5 tons), 27s. for tar (12 cwts.), 4s. 6d. for coal (6 cwts.), 6s 5d. for 200 mandrels, and 15s. 3d. for labour (running the mills, stamping machine and stove, and reaming out the bottom), or £7 3s. 2d. in all. The cost of making a tuyere bottom, 68 in. across and 26 in. deep, amounts to £6 19s. 8d. for 21 tuyeres, £3 4s. 10d. for dolomite (72 cwts.), 26s. 2d. for tar (11⅝ cwts.), 2s. 2d. for coke (2 cwts.), 2s. 3d. for coal (3 cwts.), and 5s. 6d. for labour, or £12 0s. 7d. in all. A similar bottom, of same diameter but only 18 in. deep, costs £7 12s. 6d. The cost of changing a bottom is: dolomite (1 ton) 18s., tar (2 cwts.) 6s. 9d., coke (1½ tons) 33s., labour 20s., sundries 8s., a total of £4 5s. 9d.

When a converter lining lasts out 240 charges, 6 needle bottoms are used up at a cost of £43, the expense of 5 changes being £21, or £64 in all; whereas, if tuyere bottoms are used (26 in. deep), 3 such bottoms will be needed, at a cost of £36, plus £8 10s., for two changes or £44 10s. in all, a saving of £19 10s. in favour of tuyere bottoms, equivalent to £82 10s. per month (1,000 charges). If to this be added the diminished waste of metal in the converter (0.2 per cent. instead of an average of 9 per cent.), there is a further saving of £75 per month, or altogether £157 10s., equivalent to £1,890 per annum. In this calculation no allowance has been made for the saving on the prime cost, repairs etc., of the stamping machine, repairs to furnace and the replacement of moulds. Moreover, the advantages resulting from the uniform wear of the bottoms, the possibility of increased output, and the absence of stoppages, are considerable.

The advantages accruing from the new method in comparison with those previously in use may be summarised as follows:—The increased and more uniform durability of the bottoms considerably reduces the cost of manufacturing and replacement. A tuyere bottom will last out 80 charges on the average, so that only 3 are needed to last out the converter lining (240 charges), as compared with 6 needle bottoms, which have an average life of only 40 charges. Even with cheap dolomite, 3 tuyere bottoms do not cost more than 5 needle bottoms, so that there is a saving of at least one bottom to each converter lining, apart from the saving in replacement expenses. The more regular wear and longer life of the bottoms reduce the waste of metal, the saving being so much the greater the higher the waste with badly working bottoms. The abolition of hand or machine stamping reduces the cost of skilled labour, the stamping machine is superfluous, and a larger number of bottoms can be turned out in a shorter time. Three men, one at the mixer and two labourers for making ready and pouring, can easily make 4 bottoms in 12 hours. The low drying temperature reduces the cost of renewing moulds and repairs to the drying stove, the wear on which is negligible. The ease with which the making of the bottoms can be supervised, and the uniform behaviour of the bottoms in work diminish stoppages and enable the output of steel to be increased without difficulty.

* E. Brühl, in "Stahl und Eisen."

ELECTRIC TRANSPORTERS FOR FACTORIES.

For a period of about 18 months, says "The Iron Age," the Bullock Electric Company, Norwood, Ohio a subsidiary company of the Allis-Chalmers Manufacturing Company, Milwaukee, U.S.A., has had in use a 2-ton electric industrial truck. Formerly the company found it necessary to use two railroad industrial trucks and six hand trucks to serve its factory departments. These trucks in all required ten men, while the one electric truck superseding them requires only two men. The following figures show the relative costs of the different systems for one year:—*Former Transporters*: Two industrial railroad trucks at £18 15s. each, £37 10s.; six hand trucks at £3 2s. 6d. each, £18 15s.; cost of industrial truck in factory, £104; interest for one year at 6 per cent., £9 13s.; total, about £170. *Present Transporter*: One electric industrial truck, £250; interest at 6 per cent., £15; total, £265. The difference in the initial cost of the two outfits is thus £95 in favour of the hand and industrial trucks. The following covers the comparative costs:—Former trucking force, 10 men at 8s. 4d. per day, £4 3s. 4d.; present trucking force, two men, 16s. 8d.; saving per day, £3 6s. 8d. From this it is calculated that the difference in the cost of the two systems is wiped out in the labour saving in six weeks' time. Operating on a basis of 50 weeks a year, which was the case of the Bullock plant for the past 12 months, the saving in labour approximates £916, as against the use of hand trucks. The question of depreciation is figured at 20 per cent. for both systems. No trouble has been experienced in carrying a full load of 4,000 lbs. over rough runways and down narrow aisles; loads are also carried to and from the building across the street. In serving the upper floors the truck is simply run on one of the many elevators in the different buildings and conveyed to the floor desired. Another use to which it is put is in delivering material from one shop department to another, where the overhead cranes cannot be used. The maintenance expense, exclusive of current, is put at less than £10 for the entire 18 months that the truck has been in use. Had it been necessary to buy current, the cost would have averaged approximately 1s. a day.

Copper and Aluminium Alloys.

Before a meeting of the London Branch of the British Foundrymen's Association on December 17th, 1915, M. A. Willis in the chair, Professor C. A. Edwards (Manchester University) lectured on the subject of "Alloys of Copper and Aluminium." He opened with a résumé of the internal structure of metals, and illustrated the method of crystallisation of a metal from the liquid. Micrographs were exhibited illustrating that the colour effect apparent on the surface of a microscopic specimen resulted from the incidence of the light rays. Excellent views were shown which indicated the effect of straining in producing slip bands—a microscopic appearance resulting from the crystals sliding on their cleavage planes.

Coming next to the solidification of metals and alloys, the lecturer explained by means of cooling curves the transformations which occur, with the evolution of heat, at critical points. He indicated how, by controlling the rate of cooling, the physical properties of an alloy could be quite altered. Dealing specifically with the copper-aluminium alloys, the equilibrium diagram of the series (Fig. 1) was exhibited. A brief summary of the lecturer's remarks is as follows:—A glance at the melting-point line will show that the alloy of 67 per cent. aluminium and 33 per cent. copper (the eutectic) has a very low melting point (below 550 deg. C.), while the 50 Cu.—50 Al. alloy melts below 600 deg. C. This is a useful fact in practice; for founders wishing to make the aluminium-rich alloys cannot expect aluminium, melting at about 660 deg. C., to take up copper, which melts at 1,080 deg. C., without danger of overheating. The difficulty can be readily overcome by melting the desired copper and adding gradually an equal weight of aluminium, which will make an alloy of lower melting point than the aluminum, and which is easy to add to the latter, as it is very brittle and can be readily broken up for weighing.

Referring again to Fig. 1, only the alloys at the two ends of the series are commercially valuable, as the intermediate alloys are ruled out by reason of their poor mechanical properties. Taking the copper-rich end, the aluminium up to about 8 per cent. exists in solid solution—dissolved as salt dissolves in water. Above 8 per cent. of aluminium, however, the copper is saturated, and the excess aluminium separates out as a new compound. The presence of this new compound involves a discontinuity in the properties of the alloy, as it is harder than the solid solution and renders the mixture harder. Taking the 10 per cent. Al. alloy as an example, the crystals in cooling begin to throw out of solution a new crystal with properties different from those of the parent crystal. This continues down to about 560 deg. C., when a critical point is reached at which the hard compound commences to decompose into two constituents, the first soft and malleable and the second hard and brittle. [In Fig. 2 are shown graphically test results obtained

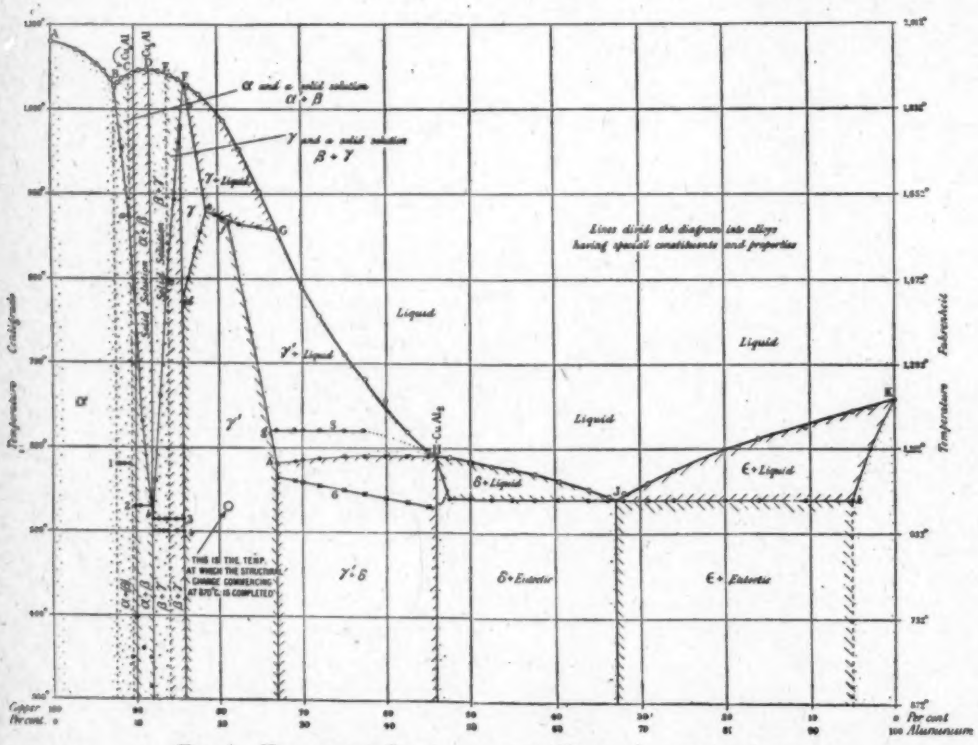


FIG. 1.—EQUILIBRIUM DIAGRAM OF THE COPPER-ALUMINIUM ALLOYS.

with ordinary sand castings of aluminium contents ranging from 0 to 13 per cent. The elongation curve is seen to drop rapidly from 8 per cent. Al., in keeping with the appearance of the hard compound mentioned. The

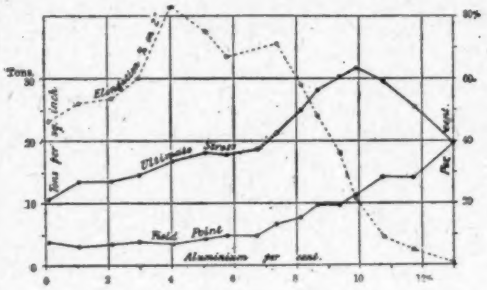


FIG. 2.—TENSILE TESTS ON SAND CASTINGS.

ultimate stress drops after 10 per cent. Al. is reached, and though the strength at this point is high, it is accompanied by excessive brittleness. The highest ductility is obtained with about 4 per cent. Al. in sand-cast

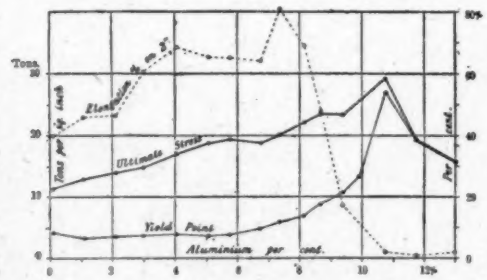


FIG. 3.—TENSILE TESTS ON SAND CASTINGS SLOWLY COOLED FROM 800° C.

alloys. The heat-treating of such castings, however, modifies these results, as will be seen from Fig. 3, which represents sand castings slowly cooled from 800 deg. C., and Fig. 4, which represents the castings quenched from

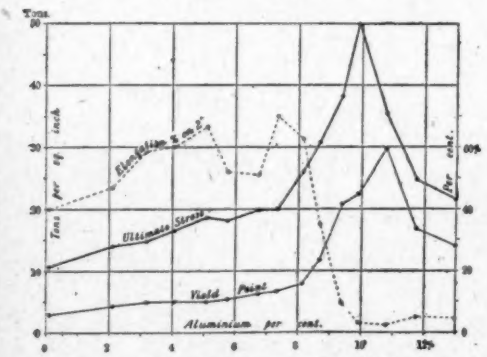


FIG. 4.—TENSILE TESTS ON SAND CASTINGS QUENCHED FROM 800° C. IN WATER.

800 deg. C. in water. It will be seen that the mechanical properties are not greatly affected by the rate of cooling until about 7 per cent. Al. is present. With more than 7 per cent. Al. (particularly at 10 per cent.) the result of quick cooling is to give a pronounced increase in the tensile strength, by reason of preventing the change which takes place in slowly cooling past the critical point. The very low ductility, however, suggests that moulders should be very cautious in removing castings from the moulds. It is a practice not uncommon with some men, when making intricately-cored castings, to take them from the sand red hot and throw them into water in order to blow out the cores. This, however, is liable to harden castings that are not required to be hard.

In Fig. 5 are shown the test results given by the alloys

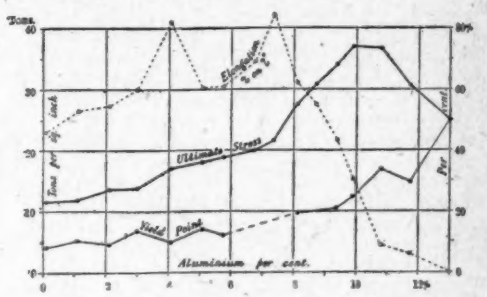


FIG. 5.—TENSILE TESTS ON CHILL CASTINGS.

cast in chill moulds. Again, there is no material change in strength produced with less than 7 per cent. Al., but with more than that amount the tensile strength is considerably improved by chilling. An examination of these results indicates that for large castings, where the rate of cooling is necessarily slower than in light work, the 10 per cent. Al. alloy should be avoided; it is impossible in heavy casting to so regulate the rate of cooling as to prevent the separation of the hard and brittle constituents, with resulting low ductility in the casting. It should here be stated that the experimental results quoted for alloys with over 7 per cent. Al. should be taken to apply only to the castings tested, which were relatively small and soon cooled; they were cylindrical bars about 4¼ in. long and 0.564 in. diameter. With

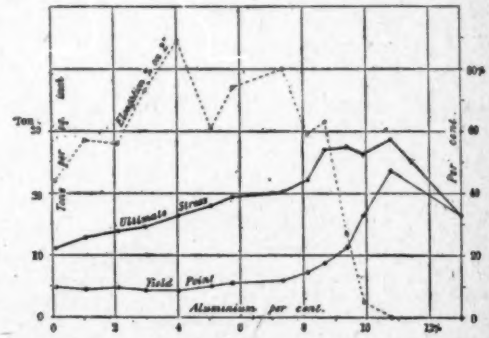


FIG. 6.—TENSILE TEST ON CHILL CASTINGS SLOWLY COOLED FROM 800° C.

larger castings poured under the same conditions the rate of cooling would be slower and the ductility correspondingly less.

In the course of the above-mentioned experiments, attention was turned to the production of cast alloy which would stand hydraulic pressure. It was ultimately found that the Cu. 90—Al. 10 alloy gave very good results when chill cast; it stood the hydraulic test up to 18 tons without showing any signs of weeping, and the

walls of the specimen had to be considerably thinned before rupture occurred, and even then they distended considerably before breaking instead of giving a brittle fracture. A difficulty was, however, experienced in getting all the castings sound, and the trouble was traced to the formation of dross from oxidation of the aluminium. The oxide accumulates on the surface of the metal, and when it is skimmed a fresh film immediately forms. The conclusion from these experiments was that it is almost impossible to prevent the formation of this dross, and that success in casting can only be obtained by arranging for the metal to enter the mould without disturbing the surface film. If the metal is poured vigorously, a wave effect is produced and the oxide is rolled over and wrapped in the metal, fresh oxide then forming on the surface, and so accumulating in the casting. The metal should therefore not be tasturbed, but should be allowed to rise gradually in the mould. The extreme tendency of these alloys to pipe and draw also necessitates having large feeder-heads and runners. When properly cast, however, quite thin sections, such as steam valves, can be made with the alloy.

In conclusion, while the more valuable results as regards tensile strength are got with copper-aluminium alloys of between 8 and 10 per cent. Al. cast in chill moulds, they are less reliable when cast in sand. When

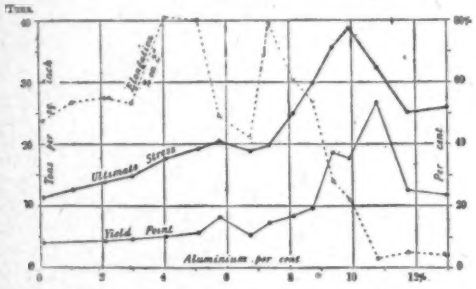


FIG. 7.—TENSILE TESTS OF CHILL CASTINGS QUENCHED FROM 800° C. IN WATER.

die or chill casting alloys containing more than 90 per cent. of aluminium the mould should be constructed so that it can be disconnected as quickly as possible and removed from the casting, so as to relieve the strains set up by contraction; otherwise there is danger of the casting fracturing. If the mould is too cold, also, it will cool the casting too rapidly and so again involve danger of fracture; for this reason the mould or die should be heated up to, say, 300 or 400 deg. C. to reduce the rate of cooling, and then be removed from the casting before contraction has proceeded too far.

Discussion.

Mr. A. WILLIS, in opening the discussion, expressed his appreciation of the lecture, remarking that it was very pleasing to see in such a favourable light the metal aluminium, which had long been regarded as "the brass-founders' curse."

Mr. J. STONE suggested that the steel-founders' practice of bottom-tapping of the pouring ladle would prevent the trouble with dross. To this the lecturer replied that it was almost impossible to overcome the formation of dross by ordinary means. Even with bottom pouring there was momentary contact between the stream of metal and the atmosphere, and oxide was formed. The only method was by using a flux which would dissolve the oxide and which could be allowed to enter the mould on the surface of the metal and wash out of the riser.

Mr. WOODS, *apropos* of the quenching of metals, asked for an explanation of what actually happened to cause hardness when a metal such as steel was quenched.

Professor EDWARDS replied that the precise nature of the hardening phenomenon had been the subject of contention—often acrimonious—for the past 20 years; but authorities were still at disagreement. There was a critical point in the cooling of steel at about 700 deg. C., at which a change took place, and quenching acted to suppress that change. The only brief explanation he could suggest was that the change in question could only be suppressed by the absorption of an equivalent amount of energy, and that quenching thus had the effect of applying internal mechanical work to the metal. As to why quenching did not harden pure copper, with pure metals there was no change in cooling such as took place in alloys, and therefore no critical point. Questioned as to whether the high mechanical properties of the 10 per cent. alloy when chilled would persist under severe vibration and service conditions, the lecturer replied that they would unless the temperature was raised abnormally—say to 200 or 300 deg. C.

Mr. BARTLETT said he assumed that the effect of quenching was to fix the condition of the alloy to which it had crystallised at the point of quenching. (The LECTURER: That is so.) Would the point from which a crystalline structure was viewed affect the appearance under the microscope by reason of one view being, for example, of the ends and the other of the sides of the crystals?

The LECTURER replied that in ordinary castings, without sharp corners or sections, that would have no effect, though it would in metals subjected to rolling, since the latter process elongated the crystals in the direction of working. Greater strength was always obtained from specimens tested in the direction of rolling than across that direction.

Mr H. SLATER desired to know what effect aluminium would have if added to steel and malleable cast-iron.

Professor EDWARDS deprecated the use of aluminium in iron and steel. It had a tendency to form a film on the surface of the casting. It was, however, used as a deoxidiser in steel practice in place of silicon, but one attendant difficulty was that it increased the piping of the steel. In cast iron aluminium could be used to render the metal greyer; a trace added to, say, a No. 3 iron would make it appear like a No. 1.

Mr. W. H. ASTON asked whether the properties of the aluminium-copper alloys would be the same regardless of the thickness of the casting. To this the Lecturer replied that, broadly speaking, they would be the same.

A hearty vote of thanks to Professor Edwards concluded the meeting.

Sand-Blasting Apparatus for File Sharpening.—A sand-blasting apparatus for file sharpening now in use consists of a sheet-iron chamber provided with uptake, settling tank, slurry mixing-tank, slurry overflow-pipe, air agitating pipe and slurry projector. A door gives access to the inside of the chamber. The slurry projector is inclined to the horizontal at an angle of 25 deg., and the nozzle extends slightly within the chamber. This projector consists essentially of a bronze body to which are fitted the steam pipe, slurry suction-pipe and nozzle. The steam supplies sufficient water for the slurry. The files are sharpened by being held in the slurry jet in such a manner as to expose the backs of the file teeth to the cutting action of the sand. The success obtained in file sharpening depends on the skilful selection of the files to be sharpened, maintenance of the correct angle between files and jet while sharpening, and the selection of a suitable sand. Experience shows that a sharpened file often does as much work as a new one, and the cost of sharpening averages about one-fifth of the cost of new files.

Die-Casting Practice.

Discussing this subject in "The Brass World," Mr. C. Pack defines die-castings as "finished castings made by pouring molten metal under pressure into a metallic mould." The process is limited to a group of alloys having a tensile strength not exceeding 20,000 lbs. per sq. in., which limits the application of this process to machine parts not subject to severe strain or shock. It is, however, possible by a careful study of the service conditions to re-design castings, either by the addition of ribs, webs, fillets, etc., or by the insertion of steel or bronze inserts to so strengthen die-cast parts that they may successfully displace the stronger alloys of copper and iron.

The design and construction of the dies constitute one of the most vital factors in the successful operation of the process. The designer of the die must find the proper location for the gate, which is a very important factor, far more so than in foundry practice. A machine part often pronounced a casting impossibility may be made a possibility by the ingenuity of the die-designer. Dies for simple parts may cost from £5 to £20; for more intricate parts from £20 to £100, and for very complicated parts die costs may run as high as £200. Although the latter figure seems high, die-castings made from such dies still show big savings.

Die-castings can be made to specifications of plus or minus 0.005 in., and when necessary, if conditions permit, to specifications of plus or minus 0.0005 in. These conditions depend upon the alloy to be used and construction of die. Generally, specifications of plus or minus 0.0005 in. can only be had on castings whose dimensions do not exceed 1 in. either way. It must, however, be understood that closer specifications require more careful die work and consequently higher die cost.

The alloys used for die-castings may be divided into three groups, viz.:—A, zinc alloys; B, tin alloys; C, lead alloys. The writer in his experience has found the constituents of group A alloys to vary as follows:—

	Per cent.
Zinc	70 to 90
Tin	0 to 20
Aluminium	0 to 5
Copper	2 to 5
Antimony	0 to 2
Lead	0 to 2

A typical example of this group of alloys is the following:—Zinc, 84.5 per cent.; tin, 9.0 per cent.; copper, 4.5 per cent.; aluminium, 2.0 per cent. Zinc alloys of the type given have a tensile strength not exceeding 18,000 lbs. per sq. in., and an exceedingly low elongation and reduction of area. The strength of these alloys compares favourably with cast iron. Zinc alloys are corroded by aqueous solutions of any kind, and should not be used for food containers or conveyors. Petrol, which theoretically should be inert towards metals, has been found to corrode zinc alloys when in direct and constant contact, due to impurities in the commercial petrol.

Of all die-castings produced in America and Europe, approximately 85 per cent. are made from zinc alloys, 10 per cent. are made from tin alloys of group B, and 5 per cent. from lead alloys of group C. Group B alloys, containing 60 per cent. and upward of tin, may be said to consist entirely of Babbitt metals. (At the present time any whitemetal alloy used for bearings is usually styled Babbitt metal.) Die-castings of this group are mostly used for motor bearings, although they are also used for machine parts where resistance to corrosion is of major importance and where high-tensile strength is not required.

In the die-casting process, the metal is poured under pressure into a water-cooled metallic mould. The rapid chilling produces a close-grained bearing, free from blows and dross spots. The alloy used by the writer is of the genuine Babbitt type, *i.e.*, containing only tin, copper and antimony in proportions varying only slightly from the original formula. No constituent is heated above 750 deg. Fah., and, after mixing it, it is kept below this temperature until cast. Parson's white brass, an alloy of tin, zinc and copper, cannot be cast in the plunger type of machine (due to freezing of plunger), and only with difficulty in the air machine. The alloy, although partially molten at 400 deg. Fah., is not thoroughly fused and entirely liquid until a temperature of 1,000 deg. Fah. is reached, at which temperature the alloy drosses excessively, segregates easily, and is in general a poor die-casting alloy. There has been, however, a demand for die-castings of the tin-zinc copper type, and this has caused the placing on the market of a bearing metal known as Comet white bronze, an alloy consisting essentially of tin, zinc and copper, in such proportions and treated in such manner as to overcome the objections to which Parson's white brass is open, although retaining its good bearing qualities.

Group C alloys, containing 60 per cent. and upward of lead, are well known, and the die-casting process is applicable to all alloys of this type.

Titanium-Aluminium Bronze.

In a recent Paper before the Detroit Foundrymen's Association, by W. M. Corse and Charles Vickers, the authors stated that the difficulties in connection with the alloy commonly known as aluminium bronze could never have been removed without extended research and able assistance from both chemical and physical laboratories. Comparatively little is known about the action of titanium in alloys. The alloy field, however, was scarcely touched until Rossi began the work that became the basis on which future development was started. Rossi patented the alloys of copper, zinc, tin, and aluminium with titanium as well as the combinations of various metals containing titanium as a deoxidiser. The Titanium Alloy Manufacturing Company, recognising the field for research in alloys, detailed Mr. Vickers to study the alloys of copper with particular reference to their possible improvement with titanium or its compounds. After three years of research the indications of a marked improvement in the copper-aluminium alloys by the addition of titanium compounds were quite conclusive. The practical result has been the organising of a bronze foundry specialising on titanium-aluminium bronzes.

The late E. S. Sperry said: "No copper alloy held out more promise at the time it was produced commercially, and none has proved more disappointing than aluminium bronze. After much good and bad experience with it, I will frankly say that it is a bronze without a peer, and the early 'worshippers' of it did not overrate it by any means. The lack of success has been caused by the difficulty in casting it, and not from any absence of merit in the metal itself. Unlike the tin bronzes, there is no tendency for the aluminium to separate in different alloys, and liquation has never been found to interfere It is safe to say that they are the most homogeneous of any known bronzes. Neither do they show the tendency to crystallise like the brasses or other alloys of copper containing zinc. They are, therefore, 'safe' alloys for construction purposes. To illustrate this point, I may say that thousands and thousands of small pins of cast aluminium bronze (10.5 per cent. aluminium) have been used by the U.S. Government in the Springfield rifle. These pins, called 'firing pins,' were used for firing the

cartridges, and were employed because steel would not stand. The greatest obstacle in the way of casting aluminium bronze is its oxidation when melted. Whenever the surface of the molten metal is exposed to the air, a film of oxide of aluminium forms on it. The more it is exposed, the greater the amount. This explains why such a large amount of dross forms when aluminium bronze is being stirred. When allowed to remain at rest in a crucible, very little forms, as the surface of the metal is protected by the film already on it. It also shows why aluminium bronze should always be poured with as little stirring as possible. Any agent, such as wet sand, which tends to stir the metal up, produces dross and the accompanying dirty castings. The more quietly aluminium bronze can be poured, the better the castings. To cast the aluminium bronze without the presence of some dross on the surface is a very difficult matter, and theoretically the right method of doing it would be to cast in a vacuum or neutral atmosphere, so that no air would come in contact with the molten metal. The only method by which it can be cast in a commercial manner is to prevent its being agitated while the pouring is taking place, either by stirring, too high a drop from the crucible to the mould, or by wet sand. Dross which forms in melting may be skimmed off, but that which forms while the pouring is taking place enters the casting. The various skim gates, pouring from the bottom, etc., are all efficacious, as they serve to trap the dross and prevent its entrance into the casting. There is no addition that can be made to overcome the dross formation, nor will any flux obviate it. The secret, if it may be called so, seems to lie in preventing the entrance of the dross into the casting, and not in its formation. While the presence of dross is the greatest obstacle encountered in the casting of aluminium bronze, it may be said that the shrinkage is the next. All strong metals shrink considerably, and in the case of aluminium bronze the shrinkage is equal to that of steel. Shrinkage is accommodated by the use of sufficiently large risers and freedom from sharp corners in the casting; with an ample gate any shrinkage may be readily overcome."

These properties were also reported by Messrs. Carpenter and Edwards, whose exhaustive treatise on copper and aluminium alloys, presented as the eighth report to the Alloys Research Committee of the Institution of Mechanical Engineers of Great Britain, and later in a Paper entitled "The Production of Castings to Withstand High Pressures," before the same body, form a classic on the subject.*

When titanium compounds are added to aluminium bronze their action seems to be similar to that in steel, viz., the removal of oxides and reduction of segregation. As the presence of oxide of aluminium is very detrimental in any alloy, and as dissolved oxygen and nitrogen should be removed, this action of titanium is of great advantage.

The practical results of the application of this theory has been to make possible the commercial production of small and large titanium-aluminium bronze castings with no more than the normal percentage of foundry loss. This does not mean that any of the precautions noted can be neglected. In fact, no alloy that we have used requires more care and supervision.

The results, however, fully justify the exercise of care, for castings of clean titanium-aluminium bronze certainly warrant Professor Thurston's opinion: "It works well, casts well, holds a fine surface under the tool, and when exposed to the weather; and it is, in every respect, considered the best bronze yet known."

*See Lecture by Prof. Edwards, page 34, and also FOUNDRY TRADE JOURNAL, April, 1915.

Melting Aluminium Chips.

In a Paper on this subject before the American Institute of Metals, Mr. H. W. Gillett remarked that a foundryman attempting to melt down the chips made in machining aluminium castings for automobiles in the same way he would melt brass chips, either by adding them in small amount to a pot of metal, or melting them alone, usually gets somewhere between 50 and 70 per cent. of the chips into a pool of metal in the bottom of the pot, and from 30 to 50 per cent. into a light, fluffy dross that, as soon as the air strikes it, gets excessively hot, glows with a blinding light, and smells of ammonia when moistened.

Experiments carried out by the American Bureau of Mines indicate that if the borings are—and those from most machine shops almost invariably are—contaminated with even two or three per cent. of fine dirt, such as floor sweepings, one can melt in a closed retort, or in an electric furnace in the entire absence of oxygen, and still get very low recoveries and copious amounts of dross. The real trouble lies in the fact that a large proportion of the chips are only about 5/1000 of an inch thick, and will pass a 20-mesh riddle. When such a chip melts it forms a globule of metal about as big as a pin point. Each chip has had an infinitesimally thin film of oxide on it, formed the moment it was cut. Such thin films prevent metallic contact between aluminium surfaces unless they are forced together so that the film is ruptured or unless a flux that will dissolve aluminium oxide is used. Each little pin-point globule is surrounded by a film of oxide, infinitesimal in thickness or weight, but yet sufficient to keep the globules from uniting. If any fine dirt is present, this reinforces the oxide armour and makes matters worse.

The dross, instead of being mainly aluminium oxide, is mainly tiny globules, separated by films of oxide and dirt. Were this not the case, and were the dross all oxide, it would not get hotter on striking the air when skimmed off. Thus, while the cold dross is oxide, the hot dross is an emulsion of metal droplets kept separate by a solid honeycomb-like structure of oxide and dirt. It is, of course, desirable to melt in a reducing atmosphere, if possible, but oxidation within the furnace is far less troublesome and far more readily overcome than the reluctance of the globules to coalesce.

Two methods of melting aluminium chips give good results. The first of these is the "puddling" process. Melting is done in oil-fired furnaces, using iron pots, the furnaces being provided with close-fitting hoods. The empty pot is heated up to a low red, and a few shovels of chips put in. The furnace tender stands by with a big skimmer and works the chips over constantly till they start to get pasty. Before they are fully melted he adds another small dose of chips and works that into the dough-like mass. The mass is not allowed to get visibly red. The addition and the working over of the chips is continued till the pot is full, holding the temperature practically at the melting point. By the constant stirring of the pasty mass, the tiny globules are pressed together, and the films of oxide and dross broken through, so that the result is a uniform pasty mass of metal, enveloping particles of dirt and oxide instead of a little molten metal below and a mass of dirt and oxide enveloping globules above. The pot is then covered and the metal heated to about 700 deg. C. or 1,300 deg. F. till the dirt and dross rise. Zinc chloride is then stirred into the risen dross, and the dross skimmed rapidly into water so as to stop oxidation and allow the recovery of entrained metal. This method gives about 70 per cent. recovery on the ordinary dirty borings of commerce. On borings cut with a water-soluble cutting compound, if the wet

borings are allowed to dry out in the air, to oxidise and cake up, the recovery by this method is 50 to 60 per cent. But if these borings are very carefully kept free from dirt and, after cutting, are promptly dried by centrifuging, these clean, dry borings give 85 to 90 per cent. recovery by this process. The puddling process requires the constant attention of the furnace tender, and the daily output per man is small.

The other process is based on the same principle, that of welding aluminium, where fluxes composed of chlorides and fluorides of the alkalies or alkaline earths are used to dissolve the film of aluminium oxide and to allow the metal surfaces to unite, fluorides being the best-known solvents for aluminium oxide as well as good ones for siliceous dirt. The chips are intimately mixed before charging with large amounts (20 to 50 per cent. of the weight of the chips, depending on the degree of cleanliness of the chips) of a flux consisting of about 85 per cent. common salt and 15 per cent. powdered fluorspar. The mixture of chips and flux is put into large crucibles, heated in a coke fire. As soon as the chips start to melt, they are jammed down to make room for more mixture, and so on till the pot is full. The pot is then left undisturbed without stirring, till the flux is fully melted and fluid enough to absorb, either by true solution, or by soaking it up mechanically, the oxide and dirt, and to allow the tiny metallic globules to fall through it and collect in a molten mass. This requires at least 900 deg. C. or 1,650 deg. F. On absolutely clean borings, this method gives 90 to 95 per cent. recovery, while chips very foul with dirt may give but 65 per cent.

The second method cannot be used in iron pots because the temperatures required are too high for reasonable pot life. It will probably require more fuel than the puddling method because of the higher temperatures and because so much flux must be heated up. The flux, though it has to be used in large amounts, is so cheap that it is hardly more expensive than the zinc chloride used in the puddling method. The crucible expense will be a little higher than that for iron pots in the puddling method, but the labour cost should be very much lower. Moreover, it is quite possible that by increasing the amount of flux to correspond with the greater surface of the metal bath in a reverberatory than in a crucible, that the salt-fluorspar flux method might be used in reverberatory melting.

Turning out Cheap Castings.

By Walter J. May.

In foundry work two classes of castings have generally to be turned out; those which have to be made of the best quality and to stand high tests irrespective of cost, and those which have to be produced at a moderate or low cost, and which have to undergo no tests, but which merely have to be sound. Possibly both classes may have to be made in the same foundry, but more generally this is not the case where castings are made by engineering works running their own foundries, as such places always specialise more or less.

When laying out a place where cheap output has to be dealt with, the class of castings produced will need consideration, and this because there are means of reducing costs very considerably. Thus the use of moulding machines, false backs in hand moulding, and other things of this character cheapen labour in the making of moulds, while a core-making machine reduces the cost in this direction where large numbers of cores of stock sizes are required. Besides such appliances as these, there are also different things in regard to the sifting, mixing and grinding of sand, carefully made flasks, and other items tending to save time, so that having in view the class of work which is to be produced, by a suitable selection of the tools used in working large savings can be made in the cost of mould production.

As wages are a very important item in all classes of foundry work, it is equally important that everything should be done to make patterns and other details favour the moulder, because in many places more time is spent in mending and patching broken moulds than in their actual production, and this simply because the make of the patterns prevents a clean lift or draw being secured. The making of one or two extra flasks per day means a large reduction in cost of production, particularly where light castings are being dealt with. Another point is to keep all patterns in good condition and well varnished, so that they do not suck the sand; for it will be found that in all but exceptional cases moulders appreciate good patterns.

Apart from labour charges, fuel has to be considered, and a good foundry coke free from an excess of sulphur is cheaper than gas coke in crucible melting, because there is less weight per part of metal used on the one hand, while crucibles burn out less on the other, sulphur being bad for plumbago crucibles.

Generally speaking, scrap metals would be used for cheap castings, and by careful sorting almost any class of castings can be produced. Take iron, for instance; if galvanised stuff is kept out, rough scrap bought from itinerant collectors will take in everything from old machinery to soft iron, and from hard and burnt stuff to old saucepans and the like, some of the older material being as good as new pig. Such scrap usually can be got at about 20s. per ton from collectors, but merchants' selected scrap costs much more.

Then with brass and gunmetal, if this is taken unsorted from the rag-shops, about 3d. or 3½d. per lb. can be managed, but even if 4d. per lb. is averaged it comes out far below what new metals would cost, and by careful sorting almost any class of casting can be produced. Even such stuff as small turnings, at a price, comes in well, but, of course, it is desirable that it should be passed through a magneting machine to remove iron. A good sorter will make a variety of qualities from a heap of mixed stuff, and will enable one to turn out almost any kind of cheap casting needed, even the poorest qualities having a use.

As it generally happens with cast-brass scrap that a fair proportion of common Continental stuff little better than brazing spelter is present, it may usually be assumed that zinc is in excess, and for this reason it is necessary to run down large crucibles where this is sorted out separately, and to use the metal for the lowest-priced castings; but for the better work the rolled scrap will come in well. Old-fashioned house bells should always be saved, as owing to their richness in tin, they work in well with gunmetal, provided they are not too freely added.

As a matter of policy it is always well to use some good make of deoxidant flux with all scrap metals, because there is the ever-present risk of having paint or other objectionable foreign matter present with some part of the charge, and this may very well cause porosity. New metal should cast clean enough, but scrap is often awkward to deal with unless outside assistance is provided.

Brass Alloy for Ornaments.—A good yellow metal for casting ornaments is:—Copper 70 per cent., zinc 26 per cent., tin 2 per cent., and lead 2 per cent. For a golden colour:—Copper 89.5 per cent., tin 5 per cent., zinc 5 per cent., and lead 0.5 per cent.

Non-Ferrous Notes.

Nickel Scrap.—When melting nickel scrap for casting, the best flux is that used by the manufacturers of nickel anodes, and consists of 1 part of fluor-spar to 3 parts of lime. The lime is slaked and the fluor-spar mixed in with it. About two handfuls are used for every 10 lbs. of scrap.

Flux For Welding Aluminium.—A new flux for welding aluminium, recently patented by Max U. Schoop, of Bois Colombes, France, is composed of:—Potassium chloride, 60 parts; sodium chloride, 12 parts; potassium bi-sulphate, 4 parts; lithium chloride, 20 parts. These are melted together and pulverised for use.

Copper-Iron Alloys.—These metals alloy in practically all proportions if pure. To produce the alloys, therefore, it is advisable to use wrought iron, as being the nearest commercially pure iron obtainable, and fuse it with the copper in a crucible. Homogeneous mixtures will be got if there is no carbon present. A flux should be used to protect the metal from the products of combustion.

Aluminium for Die-Casting.—An aluminium mixture suitable for castings made in dies under pressure consists of aluminium 80 per cent., zinc 15 per cent., tin 2.5 per cent., and copper 2.5 per cent. Aluminium also enters into ordinary die-casting mixtures of zinc base, a typical mixture of this class comprising zinc 85 per cent., tin 10 per cent., copper 3 per cent., and aluminium 2 per cent.

Arsenic in Babbitt Metal.—Genuine Babbitt metal consists of tin 88.8 per cent., antimony 7.5 per cent., and copper 3.7 per cent. In some grades of bearing metals arsenic is introduced, and when it is added to lead the metallic form must be used; but it is not usually employed, except in very small quantities, as a deoxidiser. Antimony is the proper hardener for lead, and can be employed up to 20 per cent.

Aluminium Alloys for Cooking Utensils.—A very satisfactory alloy for casting cooking utensils is:—Aluminium, 92 per cent.; copper, 8 per cent., added as a 50 copper—50 aluminium hardener. The proportions of the metal to be used in the mixture would therefore be 84 per cent. aluminium and 16 per cent. hardener. Zinc also enters into some mixtures for this work, two typical mixtures being as follows:—(1) Aluminium, 82 per cent.; copper 3 per cent.; zinc, 15 per cent. (2) Aluminium, 70 per cent.; copper, 3 per cent.; zinc, 27 per cent.

Leaded Bronze.—When using a high-lead bronze, such as 78 copper, 7 tin, 15 lead, which represent practically the maximum ability of copper to hold lead and tin in combination, lead-sweating may be experienced unless great care is exercised. The tin and lead should be introduced in combination or as a previously made alloy of 15 lead and 7 tin. This of course should be added to the molten copper just prior to pouring. Also an alloy of this constituency should first be melted and pigged, then re-melted and cast. During the pouring, in both pig-casting and the final, the metal should be stirred thoroughly at regular and frequent intervals.

Melting Brass Turnings.—However clean turnings appear to be, they are essentially in a finely divided state, and thus have excessive surface, which involves abnormal oxidation from contact with the atmosphere. They should be melted and run into ingots before being added to a mixture. When melting turnings, from five to eight ounces of 15 per cent. phosphor-copper should be added to 100 lbs. of the charge just previous to casting into ingots. The phosphorus removes the oxides which cause gas and porosity. Repeated melting of the alloy does not improve it, but only causes the deposit of an additional amount of oxide each time it is melted. If the surface of the metal in the furnace is mushy, a small handful of common salt should be stirred in, which will clear the metal; the phosphor-copper should then be added.

Recovering Tin from Scrap.—According to a method for recovering tin from tinplate scrap, etc., patented by Julius Elkes in America, the scrap is treated with yellow ammonium sulphide. It is immersed in a tank containing water, then some ammonium sulphide is added, and the whole heated until the tin is removed. The tin dissolves in the solution, and the bare iron is left. The tin is recovered by adding hydrochloric acid to the solution after it has become inactive, which precipitates it as sulphide mixed with more or less sulphur. At the same time ammonium chloride (sal-ammoniac) is formed. The solution is filtered and the sal-ammoniac recovered by evaporation. When the acid is added to the solution hydrogen sulphide gas is given off, which is passed into ammonia water and fresh ammonium sulphide is formed. The sulphide of tin is roasted after having been dried, and oxide of tin is formed.

Plastic Bronze.—The mixture consisting chiefly of copper and lead which is known as plastic bronze is used for bearings and anti-friction purposes. The composition of leaded bronzes ranges from 8 to 10 per cent. lead and 5 to 10 per cent. tin, the rest being copper, up to as much as 30 per cent. lead, the latter being the real plastic bronze. One analysis is copper 65 per cent., lead 30 per cent., and tin 5 per cent. A similar mixture is copper 64 per cent., lead 30 per cent., tin 5 per cent., nickel 1 per cent. The lead does not alloy with the copper, but separates out on cooling; but since bearings are cast and chilled rapidly, it is quite possible to cast them without marked segregation of the lead. The effect of the nickel in the alloy quoted above appears to be the formation of a better skeleton network, splitting up the lead into a greater number of small globules or particles.

Glue Binder for Brass Cores.—Among the numerous core binders for brass work, when the cores are difficult to vent and a binder that will emit only a small amount of gas has to be used, glue has been recommended. The proportion of glue to employ will vary with the hardness desired. About 1 lb. of glue is generally used to 150 lbs. of dry sand, but this proportion can be varied. The glue is melted in hot water and this solution is used to mix with the sand. If the latter is too dry, it is further tempered with water. While glue can be used satisfactorily, recent practice suggests that some of the proprietary binders now on the market are more economical and can be better regulated to requirements.

The Conductivity of Cathode Copper.—It is suggested by Lawrence Addicks (American Institute of Mining Engineers), that the reason why melted copper does not give as high a conductivity as pieces drawn directly from a cathode or native copper is that in the latter case the impurities are present as a mechanical mixture, while after melting they are chemically combined with the copper, which is a very different condition. Further, it is necessary to take the sample from a relatively smooth and consequently pure part of the cathode, as otherwise it would not draw. The same with the mass of the copper, a good solid part is picked out which is not representative. In fact, the refiners have all found they could not take fair samples of cathodes for a chemical analysis. It is always customary to use wire-bar copper for the purpose of sampling, and the impurities are several times as great as shown by samples taken from the cathodes. Copper

dissolves gases the same as other metals when it is molten; but he is not sure, says Mr. Addicks, that it is oxygen it absorbs; it may just as well be CO or CO_2. There is, however, no difficulty in getting rid of oxygen in the present type of furnace.

Phosphorus in Aluminium Bronze.—Discussing aluminium bronze in "Chemical Physics and Electro-Chemistry," Mr. A. A. Reade states that alloys containing 10 per cent. aluminium will only stand 0.2 per cent. phosphorus, as more causes the metal to give off phosphine when it is being filed or turned. The effect of very small quantities of phosphorus on annealed samples of aluminium bronze is to raise the yield point a little and increase the elongation and reduction of area very considerably, while the maximum stress remains the same. The 5 per cent. aluminium bronze will take more phosphorus than the 10 per cent. alloy, as up to 1 per cent. of phosphorus can be incorporated, and the worked metal will show no trace of phosphine. On annealed samples of the 5 per cent. alloy the effect of phosphorus is to increase slightly the yield point and maximum stress, the reduction of area being lowered as the content of phosphorus is raised. In the case of chill castings, with increase of phosphorus the yield point rises continuously and the ultimate stress attains a maximum at 0.52 per cent. phosphorus, but the elongation and reduction of area fall rapidly. Results of alternating stress tests show the deleterious effects produced by annealing the 10 per cent. aluminium bronze. Phosphorus does not appear to affect the hardness of annealed bars in small, increasing amounts, but with cold-drawn bars the hardness is slightly raised. With 5 per cent. aluminium, small amounts of phosphorus do not alter the hardness of annealed bars, but in chill castings a considerable increase in hardness is obtained when 0.25 per cent. phosphorus is passed. The electrical conductivity of the 5 per cent. alloy is only slightly greater than that of the 10 per cent. alloy; phosphorus diminishes the conductivity in both cases, being with the same amounts of phosphorus twice as great as in the 10 per cent. alloy. Phosphorus is found to lower the melting point of both alloys. Pure, fresh water has an exceedingly small corrosive action on these bronzes, while in the case of sea water the effect of small quantities of phosphorus is to reduce the loss of weight due to corrosion.

Disintegration of Alloys.—A feature around which much discussion has turned, especially since the rise of aluminium to the plane of a commercial metal, is the disintegration of alloys during the progress of time, apart from the generally recognised corrosion to which most metals may be subjected. Aluminium alloyed with tin may give at first a tensile strength two or three times as great as that possessed a few weeks later by the same specimen. When cast the structure of that alloy may show a firm, close grain if examined under the microscope, but later entirely different crystals. The fracture of the new casting has been noticed to give off an odour of silicon hydride, and it is suggested that the presence of water in such cases produces a gas which rots the alloy. It is possible that through overheating the aluminium takes up silicon from the crucible. Ivinson advises that these alloys be melted without fluxes such as mixtures of sodium and potassium chloride. Zinc chloride acts upon the crucible and the aluminium dissolves out the silica, which, in the presence of moisture, liberates silicon hydride that, it is claimed, in time causes the disintegration leprosy of the alloys. Ivinson advises phosphide of copper added in quantites of 1½ per cent. to a zinc-aluminium alloy containing from 12½ to 15 per cent. zinc to give fluidity to the melted metal. Phosphide of zinc containing 25 per cent. phosphorus can be substituted advantageously in the proportion of 0.05 per cent. It should be added to the alloy when molten a few minutes before pouring. As against the foregoing contentions, Goldberg, from investigations at Grosslichterfelde, considers that neither silicon nor nitrogen plays any important part in the disintegration of aluminium articles while in stock prior to being used. He found the crust and blisters to consist almost wholly of alumina. Changes of temperature were without influence. Distilled water had less corrosive action than the untreated water, particularly as regards irregular and local pitting. His conclusions were that the trouble was electrolytic, and depended in the main upon differences of potential between unequally hard portions of the aluminium. For the cure of this condition he suggested that the work should be carefully heated to 400 to 450 deg. and then slowly cooled.

Over-Heating of Metals.—It is well known that the melting points of the metals which pass through the hands of the founder vary very considerably, ranging from 232 deg. C. in the case of tin to 1,452 deg. C. in the case of nickel; with copper, the base of all brasses and bronzes, at 1,083 deg. When it is recalled that a metal's power of combination with the oxygen of the atmosphere is greatly increased with rise in temperature, it will be seen that the avoidance of excessive heat for any metal is important. Founders recognise that overheating a metal may cause it to "burn" and acquire undesirable properties, but it is not always clearly understood that this burning is essentially the same as the burning of a fuel, *i.e.*, its combination with oxygen. Though oxidation of a metal (unless in an extremely fine state of division) proceeds much more slowly and does not generate sufficient heat to propagate combustion, that does not affect the actual fact. The mere heating of the metal without contact with oxygen is not detrimental, as is evidenced by the fact that the smelting operation or the separation of the metal from its natural combinations generally involves a much higher temperature than is obtained in founding the metal, smelting, of course, being conducted in a reducing (as distinguished from an oxidising) atmosphere.

In foundry practice the maintenance of a reducing atmosphere around the molten metal is not yet a practicable matter, so the founder has to take the next best course and protect the metal as far as possible, while at the same time avoiding excessive heat which would aggravate the inevitable exposure. The first rule, then, is that a metal should not be over-heated in melting, and to avoid this when metals of divergent melting points are to be alloyed it is necessary to melt first the high-melting-point metals and add the others to the molten metal. A characteristic of alloys which affects this matter is that the melting point may be and generally is lower than that of the mean of the constituents on the basis of volume. For example, two metals of almost equal melting points when alloyed may have a lower melting point than that of either of the original metals. This, however, is not always so when taken on the basis of weight, as gunmetal (88:10:2) melts at 995 deg. C., whereas the mean of the constituent melting points in the proportions of 88:10:2 in weight is 985 deg. The volume ratio of this alloy is about 90:8.4:1.16, the mean melting point of which works out at about 1,000 deg. C. Defects in aluminium castings are often directly traceable to overheating of the metal during melting. Aluminium has a strong affinity for oxygen, and will absorb it from almost any element, provided the temperature is sufficiently high. The temperature during melting should never be permitted to exceed that of dull redness, as the copper-aluminium hardening, when that is used, is incorporated easily at a comparatively low temperature.

Correspondence.

[We accept no responsibility for the statements made, or opinions expressed, by our Correspondents.]

OXIDATION OF ALUMINIUM IN MELTING.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—With reference to your issue of November, we note that in the editorial remarks on aluminium castings (page 584) it is mentioned that aluminium oxidises so quickly as to make it difficult to prevent dross entering the mould. It is also stated that the metal is very liable to be overheated. The Monometer system of melting aluminium practically eliminates the oxide, as the melting chamber is entirely closed, and the inert gases are conducted to this chamber, thereby preventing free oxygen from attacking the molten metal. Further, it is impossible to burn the aluminium in the system in question, as low-pressure burners without fans or blowers are employed, while to keep the temperature within control a self-acting heat controller is fitted. This instrument operates on the thermostatic principle, and by actuating the valve so controls the gas supply as to prevent the temperature from exceeding a predetermined maximum.—Yours, etc.,

MONOMETER MANUFACTURING COMPANY, LIMITED.

Birmingham.

SILICON COPPER.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—I read with interest the "Non-ferrous Notes" in the November issue of the JOURNAL, and the one I was especially interested in was the note on silicon-copper, which states: "The principal use of silicon-copper is as a deoxidiser of copper; it reduces the electrical conductivity of the copper, but is applicable for all copper castings in which this property is unimportant. The addition of 1 per cent. of 10 per cent silicon-copper reduces the electrical conductivity to about 57 per cent."

These statements are, I think, apt to make one believe that silicon-copper is *not* applicable for high-conductivity copper castings. Is it not the theory that silicon, used as a deoxidiser of copper, should be used only in sufficient quantity to remove the oxygen taken up by the copper in the course of melting, and that silicon, by reason of its greater affinity for oxygen, will combine with that element to form silica (SiO_2) thereby reducing the oxide of copper, and that silica, being insoluble in copper, and much lighter, will rise to the surface of the molten copper and be removed? If this theory is correct, how does it happen that the conductivity is reduced to 57 per cent., when the silicon should not remain in the copper?

The note further states that the addition of a small amount of silicon, in this case 0.1 per cent., makes a big difference in the electrical properties of the copper, but, taking into consideration the difference in the specific gravities (silicon 2.49 and copper 8.82) 0.1 per cent. *by weight* assumes quite a different proportion *by volume*.

Personally, I do not think the amount of silicon necessary for the purpose can be suggested, unless one knows the treatment the copper has received and the grade of copper used. A great deal depends on the fireman. If he is careful, the copper will be practically constant so far as melting is concerned, and will require a constant amount of silicon-copper. A careless fireman will never know how much is required, because no two lots of his copper will receive the same treatment, and to make certain he will use about 50 per cent. more than is necessary. A few hints on the treatment of copper for casting purposes may not be out of place:—

Always keep the metal under a good covering of small charcoal, a portion of which should be placed in the bottom of the crucible before the copper.

Bring the metal up to a good heat.

Never use an iron poker or skimmer to stir the metal after the silicon-copper has been added; but use a plumbago stirrer

Break up the silicon-copper into very small pieces, which may be wrapped in paper for convenience, and add to the copper immediately *after* the crucible has been removed from the fire.

Stir well, but do not on any account remove the covering of charcoal; this is very important, and the charcoal can always be held back during casting operations.

Use rather heavier gates than for gunmetal, and increase the height.

Strip away the sand as soon as possible after casting, to allow shrinkage to take place; omission to do this may cause breakage. All cores should be made as yielding as possible for the same reason.

A properly deoxidised copper will cast just as well as any other metal, and will behave in just the same manner after being cast; it will "sink" in the gates. Copper that is not properly deoxidised will, as soon as the temperature has fallen sufficiently low, commence to "run back" or bleed, and will even overflow the heads, or it may only show a gate with a convex surface. But whichever of these faults shows, it is a certain indication that the casting underneath is useless. I would also suggest that each person conduct his own experiments, as only by experiment can the proper amount be determined. Commence by using a small amount, say 4 ozs. per 100 lbs. of copper, or even less, and advancing by ½ ozs. until good results are obtained.

In conclusion, let me say that a copper casting made as stated will give a much better result for relative conductivity than 57 per cent. In passing, there are in use to-day thousands of miles of silicon-bronze telegraph wires with relative conductivity of over 90 per cent. and a tensile strength of 28½ tons per sq! in.—Yours, etc.,

A. J. HOBSON.

South View, The Square,
Wyke Regis, Weymouth.

[It was perhaps not made clear, in the note above referred to, that the electrical conductivity was reduced by the quantity of silicon mentioned being left in. Obviously, if the silicon combines with oxygen and is removed it leaves the copper purer and of higher conductivity; but the difficulty of correctly proportioning the silicon to the unknown quantity of oxide present too often results in a residue of silicon remaining in the copper, with the results stated. We endorse our correspondent's remarks in regard to experimenting to ascertain the correct addition to make for any particular class of copper.—EDITOR, "F.T.J."]

Standardisation of Bomb Calorimeters.—There has been issued by the Bureau of Standards of the United States Department of Commerce a paper describing briefly the methods of calibrating and using bomb calorimeters, such as are used in determining the amount of heat available from a given weight of coal or coke or other combustible. Provision is made by the Bureau for standardising bomb calorimeters by means of standard samples which are sent all over the United States, to serve as standards of heat and make it possible to get the same results from tests made anywhere in the country.

Open-Hearth Furnace Chequer Design.*

By W. A. Janssen.

It is only within the past decade that designers have realised the relatively low efficiency of open-hearth furnaces, and have directed their efforts toward chequer design to obtain maximum heat conservation. The relative sizes of air and gas chambers, as designed for a furnace using producer gas as fuel, has always been a moot question. In general, it may be said that their proportions are in the same ratio as the calorific capacity of air and gas simultaneously heated. This total capacity ratio is calculated on the basis of moisture-free air and gas for the temperature gradient at which they enter the regenerator and are desired to enter the hearth. This ratio is approximately that each volume of gas requires 1½ volumes of air. The empirical volume of air and gas chequer, therefore, is about 1½ to 1. This ratio, however, is not strictly adhered to inasmuch as about 10 per cent. more air is used than is necessary for complete combustion, and the gas need not be heated to quite as high a temperature.

Aside from accuracy of relative volumes, the dependence of length, breadth and depth are important factors of design. In determining the length of the regenerator in line of gas travel to the stack, it must be borne in mind that the gases must pass through at a slow velocity rate, thereby being assured of a proper cooling of the outgoing gas before going to the stack, and a proper heating of the incoming air and gas before entering the furnace. In other words, the larger the cross-section and the lower the velocity, the shorter the length, and the more reduced the cross-section and the greater the velocity, the greater must be the chequer length. A satisfactory chequer length depending on cross-section is 15 or 20 ft. The cross-sectional area of the chequer, whereby is meant the aggregate area of the free air spaces, should be so designed that the gas velocity be not greater than 10 ft. per second. The gas passages must be large rather than small, as a safeguard against retardation of gas flow due to friction. It also must be remembered that the area of these passages is constantly being reduced, due to deposition of particles of slag, ore dust, and other materials from the outgoing gases, resulting in further frictional retardation due to the rough surfaces.

With a knowledge of maximum gas temperature, and the quantity and velocity thereof passing through the regenerator, the free passage area may be readily determined. With this information and the amount of space occupied by the chequer brick, the cross-section of the chequer may be calculated.

Depth.—Apart from the length and cross-section of the chequer, the function of depth must not be lost sight of. The chief function of chequer depth, apart from augmenting ideal cross-section, is to expedite the flow or travel of the incoming air and gas because of the stack-like draft effect which is directly proportional to depth. If the chequers are made deep instead of shallow, the incoming gases are forced by this natural draft to seek the hot places, and the outgoing gases to find the cool areas; thus, automatically, the regenerator temperature is equalised throughout. In early designs, when the chequers were placed beneath the hearth the draft effect of the deep vertical regenerators was greater than that of the present-day long horizontal type, wherein often there is no propelling force, except the port uptakes.

The chequer volume, whereby is meant the aggregate volume occupied by filled and free air spaces, usually is referred to in terms of per ton of furnace capacity. This volume does not include that portion above the chequer brick or the flues underneath. In early design, 50 to 75 cub. ft. per ton of rated furnace capacity was considered good practice. Present-day design allows between 85 to 95 cub. ft. per ton, and in one or two instances up to 110 cub. ft. It is evident that the larger the chequers the greater will be the amount of heat conserved, and the lower the temperature of the gases going to the stack. This, however, might be carried to such an extreme that the temperature of the outgoing gases would be equal to that of the incoming, thereby eliminating the propelling force of the cold gases seeking the hot areas. In addition to this, the maximum temperature would be so much reduced as to be insufficient for efficient flame combustion. The high cost of refractories also would limit the building of abnormally large chequers even if they were desirable. The chief function of the regenerators is to conserve sufficient heat units of maximum temperature to heat the incoming air and gas to a temperature high enough for efficient flame combustion. The temperature of outgoing gases from a chequer so designed will be about 300 to 500 deg. C.

Brick Arrangement.—Each designer has his own opinions regarding chequer brick arrangement. The fundamental fact which must be borne in mind, however, is that the arrangement must be such as to offer a maximum area for absorption and a minimum retardation to gas flow. In addition to this, the facility with which bricks may be cleaned at the end of a campaign must be given consideration. In the old-time arrangement, which is still popular even to-day, wherein the bricks were so laid as to produce both vertical and horizontal flues, it was almost always necessary to remove all bricks for cleaning at the end of a campaign, resulting in much breakage and increased repair costs. When the bricks are laid to produce either vertical or horizontal flues, the flue may be cleaned with a boiler flue brush at the end of a campaign, thereby eliminating brick removal.

Silica Brick Chequers.—It has long been the practice to use firebricks for chequers. During the past few years the use of silica bricks, because of their increased conductivity, has come into favour. The first cost of silica bricks is higher, but the gain in efficiency and economy warrants their use. The writer has in mind an installation in which silica chequer bricks were used, from which 2,500 heats were tapped before it became necessary to replace the bricks, except the first two top courses, at the end of a campaign.

The investigations of Queneau, Wolodigne and Osann on the heat conductivity and gas permeability of commercial refractory materials seem to indicate with certainty that the temperature at which bricks are burned influences the heat conductivity, *i.e.*, the higher the burning temperature the greater is the conductivity. Even though a correct burning temperature might be attained, it would be difficult to exact such requirements from a brickmaker. It also was found that conductivity increases with temperature. The maximum temperature of the chequers in general is unknown until the furnace is in actual operation. To design a brick to withstand

* From a paper read before the American Foundrymen's Association.

this temperature might necessitate the specification of a special mixture which might offset the desired burning temperature. With a specific knowledge of the conductivity of the various refractory materials and the amount of heat which must be conserved between reversals, a brick of ideal dimensions, which undoubtedly would be smaller than a commercial brick, might be designed. The efficient conductivity of the ideal brick would be influenced by the reducing action of carbon monoxide on the iron content of the brick mixture and by the carbon deposition due to gas permeability in the heart of the brick. The gas permeability and carbon deposition in all probability are the fundamental causes of chequer brick deterioration. All of these theoretical considerations would seem to indicate that the ideal chequer brick would be smaller in cross-section than those of present practice. The advantages which they might have are offset by decreased life, increased cost of manufacture, and breakage in handling. The decreased life would necessitate more frequent replacement of chequer brick and would increase repair cost.

Of equal importance with chequer design is the proper dependent design of ports, sewers for incoming gas and air, and flue to the stack.

The Moulder's Craft.

A discussion on a Paper by Mr. J. McNamee, entitled "A Journeyman Moulder's Opinion of his Craft," took place at a recent meeting of the Newcastle and District Branch of the British Foundrymen's Association. A summary of Mr. McNamee's Paper appeared in our issue of June, 1915.

The CHAIRMAN (Mr. M. E. Gallon) asked Mr. McNamee if he considered it an honourable thing for an apprentice, if he were treated as well as he had a right to be by his employer, to shift from one shop to another.

Mr. MCNAMEE, in reply, said he considered that if an apprentice were treated properly he should remain, but if he were made merely a productive unit then he should move to another shop. He believed there were foremen who would do really better than they were doing at the present time if it were not for the economic pressure they were under.

Mr. EDWARD SMITH (South Shields) said in his opinion in nine cases out of ten the apprentice would benefit by a change. It might not seem fair on the face of it to an employer who treated his men properly, but one did not get the same experience by remaining in one shop as one did by moving about to different shops. To move about in good shops was all to the advantage of a young man. With regard to men being allowed to make experiments, he thought it would be an expensive undertaking if everyone who thought he could do a thing better than it was being done was to be allowed to carry out experiments. Experience had shown that a lot of these so-called experiments had proved failures. He was sure no employer in a well-conducted foundry would be above taking a suggestion from any moulder if he would give his opinions. He (the speaker) was a great believer in education, but he could not say that he believed education would make a better moulder, because in his experience the men who had had the least education had been the best moulders. He did not say that education stopped men from being moulders, but men with no education had often been the most successful in their craft. There was a sense of touch in a green-sand moulder, for instance, which no amount of scientific or other higher education would make keener or more perfect. Besides that, when a man was educated in the higher branches of science he became dissatisfied with the calling. An educated lad could never be got to stop in the foundry; in the dirtier branches of industry education did not improve men. Some successful moulders, if they had had more education or more sense, would not have stopped at their craft as long as they had done. (Laughter.) Mr. McNamee had deplored the fact that they had no formulæ in the foundry. He (the speaker) thought that an utter impossibility. They could not get a universal formulæ where the conditions of every shop were different.

Mr. JAMES SMITH (South Shields), referring to the lecturer's remarks on cupolas, said if the results were right one day, with the same treatment they should be right every day. No matter how old or how new a furnace was, if it was rightly constructed and if it melted iron properly, it should melt iron properly every day. It depended practically upon the man in charge of the furnace. With reference to the education of the lads, in his opinion foundrymen were now deteriorating. He conscientiously believed that the foundrymen of to-day were not what they were 30 years ago. There were proofs of that every day when men asked for a job at the gates. They could not educate lads to be moulders. There was now too much card-playing and football, and in their spare time lads would much sooner learn to play "nap" than improve themselves in their craft. Education would not make moulders; it all depended upon the lads themseves. Unless a foundry foreman got hold of the right men he would not get the right quality of work.

Mr. W. J. PAULIN (Heaton) said certain correspondence classes in connection with education added to a young man's knowledge just sufficient to give him swelled head—gave that little smattering of science which upset his mental balance. In his opinion the practical man was the theoretical man, although he often did not know it. He had theories in his head not from mathematical equations, but he turned to formulæ in his head, and although he never described the process to anybody or put it on paper, yet he was thus working in the best school for practical experience. One of the chief difficulties was to get a lad to understand that he was being actually educated in the shop. What did men discuss at the dinner hour? If any one ventured to introduce a little scientific problem the others were down on him for "talking shop." That attitude was an absurdity; he himself had found more value from "talking shop" than from attending many science clubs. Nowadays too much was made of so-called technical education. Education was not a panacea for the troubles of all trades. They wanted keener application of the sort of science that could be learned and applied in the shop.

Other speakers took part in the discussion, and in the course of his reply, Mr. MCNAMEE said he only advocated experiments when they were conducted in conjunction with the foreman. Education, he agreed, would not make a moulder, but if an apprentice studied science he believed it would assist him in regard to his artistic touch and taste and in the interpretation of his desires. He had worked with a man who could neither read nor write, and he was the smartest moulder he had met; and another smart moulder he knew could only count his weekly wage.

Mr. McNamee was cordially thanked for his Paper.

Removing Zinc from Soft Alloys.—In some classes of alloys zinc is regarded as an undesirable impurity, for example, in solders, type metal, etc. To remove it the metal should be constantly stirred while melting, and the dross, which will contain the zinc, skimmed off from time to time.

Trade Talk.

THE SWEDISH GOVERNMENT has added wolfram, vanadium, and carbon electrodes to the list of prohibited exports.

THE shareholders of the Variable Blast Pipe Company, Limited, have decided to wind up the company voluntarily.

MESSRS. E. H. BUTLER & G. F. BUTLER, engineers and tool makers, 28, Park Street, Birmingham, trading as T. Butler, have dissolved partnership.

THE MANCHESTER METAL STAMPING AND ENGINEERING COMPANY, LIMITED, have established themselves in business at 336–40, Chester Road, Manchester.

THE waste heat plant at the Cleator Moor works of the Whitehaven Hematite Iron and Steel Company, Limited, was officially put into operation on December 2.

THE SHEFFIELD ELECTRICAL ENGINEERING COMPANY, LIMITED, is being wound up voluntarily, with Mr. H. Cawood, 68, Eyre Street, Sheffield, as liquidator.

AN outbreak of fire has occurred on the premises of Steel Castings, Limited, 253, Old Edinburgh Road, Parkhead, Glasgow. Considerable damage was done to the engine house.

THE shareholders of the Feralium Rustless Metal Company Limited, have decided to wind up the company, voluntarily, with Mr. G. A. Joyce, 94, Hatton Garden. London, E.C., as liquidator.

THE estates of the Glasgow Harbour Foundry Company, Moorpark, Renfrew, and of J. Wilson and T. Hill, the partners, were sequestrated on December 18 by the Sheriff of Renfrew and Bute at Paisley.

MOSES EADON & SONS, LIMITED, who recently acquired the Russell Works, Kelham Island, Sheffield, have now transferred their works and office thereto, and have renamed them the President Works.

THE shareholders of Wilsons, Pease & Company, Limited, will meet at the offices of Pease and Partners, Limited, 92, Northgate, Darlington, on Wednesday, February 16, to consider the liquidator's report.

MESSRS. JAMES DOVE & COMPANY, engineers, Edinburgh, have suspended payment, and granted a trust deed on behalf of their creditors in favour of Mr. C. J. Munro, 50, Frederick Street, Edinburgh.

THE announcement has been made that the Redcar Ironworks, Middlesbrough, of Walker, Maynard & Company, Limited, have been purchased by Sir Hugh Bell, Bart., and Mr. A. J. Dorman, and will be re-started very shortly.

MESSRS. J. BILBIE, J. S. WYLDE, AND H. G. HALE, carrying on business as engineers, at 106, Queen Victoria Street, London, E.C., and Deverell Street, Great Dover Street, S.E., under the style of Bilbie, Hobson & Company, have dissolved partnership, so far as concerns Mr. H. G. Hale.

COLE, MARCHENT & MORLEY, LIMITED, of Bradford, Hick, Hargreaves & Company, Limited, of Bolton, and the Edison & Swan United Electric Light Company, Limited, of London, have been elected members of the British Electrical and Allied Manufacturers' Association.

SAMUEL RUSSELL & COMPANY, LIMITED, of Northcote Street Foundry, Walsall, and Thos. W. Ward, Limited, of the Albion Works, Savile Street, Sheffield, have become members of the Bribery and Secret Commissions Prevention League, Incorporated.

THE shareholders of the Carnforth Hematite Iron Company, Limited, have passed a resolution to the effect that the company be wound up voluntarily. Mr. E. H. Walker, of 4, Chapel Walks, Cross Street, Manchester, has been appointed liquidator.

THE names of the undermentioned companies have been struck off the Register of Joint Stock Companies, and such companies are dissolved: Castings Repair Company, Limited, Hope Foundry Company (London), Limited, Rustless Metal Company, Limited, and the Wolf Engineering Company, Limited.

IN 1894, the firm of Messrs. Thomas Nicklin & Son, of the Old Crown Ironworks, Smethwick, near Birmingham, suspended payment, owing to serious losses. The surviving partner, Mr. J. C. Nicklin, went into another business and was successful. Recently he paid off his half-share of the debts of the old firm of 20 years ago.

MR ALAN WILLIAMS has removed from 9, Queen Victoria Street, E.C., to larger offices at 5, Chancery Lane, W.C. In addition to his electrical and general engineering business, Mr. Williams represents the Anderston Foundry Company, Limited, of Glasgow, and the British Electric Plant Company, Limited, of Glasgow and Alloa.

BY an Order in Council, published in the "London Gazette," the exportation of hematite pig-iron and iron and steel scrap is prohibited to all destinations. The export of solid drawn steel tubes and material for wireless telegraphs is prohibited to all destinations other than British Possessions and Protectorates.

THE MITSUBISHI GOSHI KAISHA, of Tokyo, have established a branch at 149, Leadenhall Street, London, E.C. In addition to their business of bankers and merchants, the firm is well known throughout the East as producers of electrolytic copper, wolfram and tin ores, and other metals, and proprietors of the dockyards, shipbuilding and engineering works at Nagsaki and Kobe, etc.

THE officials of the ammunition department of Sir W. G. Armstrong, Whitworth & Company, Limited, held their annual dinner on December 13, the numerous company including Mr. N. A. Lee, of the Elswick Works, who succeeded Mr. West when the latter was transferred to the Ministry of Munitions, and Mr. Charlesworth, of the Scotswood Works, who presided.

THE Minister of Munitions announces that he has made an order under Section 4 of the Munitions of War Act, 1915, declaring 396 additional establishments as controlled establishments under the Act, as from January 1, 1916. A total of 2,422 establishments have now been declared as controlled under the Act, from the date of the first order, July 12, 1915, to January 1, 1916, inclusive.

AT a meeting of the Rugby Engineering Society it was decided that no papers or lectures should be given before the Society this session, in view of the fact that the time of the officials and members was largely occupied with war work, and that owing to so many members having joined His Majesty's forces the effective membership was greatly reduced. As far as possible the officials who were elected for session 1914–15 will continue to serve for the present session.

In debate on the Munitions Amendment Bill, on December 7, Mr. McKenna moved an amendment providing that is respect of the excess profits duty the commissioners of inland revenue should have power to allow modifications to meet the case of a firm who, owing to the present war, had been under the necessity of providing plant which would not be wanted for the purpose of the trade after the termination of hostilities. The amendment was agreed to.

THE BRITON FERRY STEEL COMPANY, LIMITED, of which Mr. Herbert Eccles, J.P., is the managing director, has purchased the works of the Baglan Engineering Company, Limited, Briton Ferry, and the merge will take place very shortly. It is only about six months ago that the Briton Ferry Steel Company took over the Albion Steelworks at Briton Ferry, which are now being much enlarged. The Baglan Engineering Works were erected about twenty years ago, and have been working ever since.

AT the Glasgow Dean of Guild Court, recently, the following improvement schemes were sanctioned: A. & J. Main & Company, Limited, Clydesdale Ironworks, Possilpark—To make an extension to their girder shop at Clydesdale Ironworks, Possilpark. William Beardmore & Company, Limited Parkhead—To erect offices in Old Edinburgh Road. Archibald Low & Sons, Limited, engineers and brass founders, Merkland Street, Partick—To make additions to their works there.

MESSRS. WALLIS-JONES & DENT, consulting engineers, 50, Queen Anne's Gate, Westminster, London, S.W., announce that in consequence of the absence of Captain Wallis-Jones on active service, Mr. H. W. Couzens, of Messrs. Couzens & Brown, has undertaken to execute on their behalf all work now in hand and any future work that may be entrusted to the firm of Wallis-Jones & Dent. Mr. Couzens will have the services of Mr. Tate, for many years Messrs. Wallis-Jones & Dent's chief assistant engineer.

AN interesting contribution on the work of engineering colleges in connection with the war was read on December 17 before the members of the Institution of Mechanical Engineers. The paper was read by Mr. D. R. Mullineux Walmsley, Principal of the Northampton Polytechnic Institute, London,

and was the joint work of himself and Mr. C. E. Larard, head of the Civil and Mechanical Department of the same institution.

The sixth annual iron and steel and allied trades dinner in connecton with the Manchester and District Bowling Club of that designation was held on Saturday, December 4, at the Victoria Hotel, Manchester.

THE subject of steel scrap exports was dealt with in the House of Commons on December 8, when Dr. Addison, replying to a question of Mr. Hodge, said that he was informed that the amounts both of heavy steel scrap exported to France and of light scrap imported from France were not sufficient to exercise any appreciable effect upon the problem of transport. Steps to control the export of heavy scrap had, however, already been taken.

A MEETING of the Sheffield section of the Junior Institution of Engineers was held on December 3 at the Cutlers' Hall, Mr. F. W. Mellowes presiding. Mr. J. R. Williams, vice-chairman, presented the silver medal of the Institute, for the best paper read last session, to Mr. J. R. Hyde, of the Abbeydale Foundry, whose subject was "Comparative Properties of Iron, Malleable Iron, and Steel." Mr. T. A. Brown, a member, read a paper on "Automatic Feed Water Regulators."

THE BOARD OF CUSTOMS have issued the following notice concerning the export of prohibited goods: Exporters and others concerned are reminded that it is an offence under Section 8 of the Customs and Inland Revenue Act, 1879, to bring prohibited goods to any quay or other place to be shipped unless the exportation of such goods has been authorised by a Privy Council licence. The penalty for this offence was increased by Section 2 of the Customs (Exportation Restriction) Act, 1915, to £500 or imprisonment, with or without hard labour, for two years.

THE text has been issued of a Bill to make provision with respect to companies of enemy character. The principal object of the Bill is contained in the first clause, which reads: "Where it shall appear to the Attorney-General that any company registered in the United Kingdom is, owing to the character of its directors or of its shareholders, or to any other cause of a predominantly enemy character, he shall present a petition to His Majesty in Council praying that such company may be declared by His Majesty in Council to be an enemy company."

A FURTHER list of the awards at the Panama-Pacific Exposition has now been received from the British Commissioner at the Exposition. Successful British exhibitors include the following:—Department of Machinery: Jno. Hy. Andrew & Company, Limited (tool steel and mining steel), gold medal; Edward G. Herbert, Limited (tool steel and file steel testing machines), gold medal; Seebohm & Dieckstahl, Limited (steel manufacturers), gold medal.

MR. JAMES CLEMENTS, steel, iron, and metal merchant, of Highbury Chambers, Skinner Street, Newport, Mon., has transferred his business to Mr. Wm. H. Hollingdale and Mr. J. Matthews. Mr. Hollingdale has been closely associated with Mr. Clements for 26 years past, and Mr. Matthews for the last 20 years. The business will be continued under the style of James Clements & Company. Mr. Wm. H. Hollingdale has for many years been secretary of the Newport Metal Exchange.

MESSRS. EDWD. RILEY & HARBORD have removed their laboratory, mining and assay offices from 2, City Road (14a, Finsbury Square), London, E.C., to 6, Finsbury Square, E.C. The business is being continued under the superintendence of Mr. F. J. Bolt and Mr. F. W. Jordan. The Westminster Laboratories, 16, Victoria Street, S.W., will continue as hitherto. Mr. C. O. Bannister, formerly head of the Metallurgical Department of the Sir John Cass Technical Institute, has now joined the staff.

THE prize distribution at the Northampton Polytechnic Institute took place on December 18th. In the course of his report, the Principal detailed the effect of the war on the educational work of the Institute. When the enrolments were made up at the end of the session it was found that the total number of students during the session had been 1,748, as against 2,101 in the preceding session. The students' hours fell from 121,625 to 78,956, which is much more than 24 per cent. More eloquent still is that the number of hours worked by each individual student fell from 70.6 to 48.

MR. H. ETCHELLS lectured before the Sheffield Society of Engineers and Metallurgists on December 13th, on "Electrical Steel Melting Furnaces." The meeting was held in the Mappin Hall, under the chairmanship of Mr. G. Rodger. Prior to the lecture, the following officers were re-elected: Hon. treasurer, Mr. C. K. Everitt; hon. secretary, Mr. E. C. Ibbotson; assistant-secretary, Mr. E. J. Thackeray. Mr. J. Little was appointed an auditor, and Messrs. J. Little, P. Longmuir, E. H. Saniter, and B. W. Winder, the retiring members of the council, were re-elected.

THE Sheffield steel manufacturing firm of Seebohm & Dieckstahl, Limited, of which Mr. Arthur Balfour is the head, will in future be known as Arthur Balfour & Company, Limited. Mr. Balfour is the principal shareholder and managing director, having originally entered the works as a boy. The directors of the firm, besides Mr. Balfour, are Mr. G. S. Watson, Mr. H. E. Hollis and Mr. R. W. Marshall, and with the exception of the company's agent at Liége, who is a Belgian, all the shareholders are British.

IN the course of a speech on the supply of munitions on December 20, Mr. Lloyd George pointed out the economy which had been effected in taking control of the metal market. One had only to examine the prices in this country and compare them with the prices of similar metals in America and elsewhere to find how substantial those economies were. We had saved in the course of a single year something just about equal to 6d. or 7d. in the £ of income tax in the metal market alone.

THE opinion has frequently been expressed that to obtain the highest efficiency from industrial workers, it is necessary that rational recreation and relaxation should be provided. In view of this, it is particularly interesting to find that Vickers, Limited, have built a modern and most attractive picture and variety theatre in the neighbourhood of one of their large works. Canteens are already being provided in considerable numbers, but the addition of suitable places of amusement must necessarily assist very materially in promoting the welfare and contentment of the workers.

A NOTIFICATION has been issued by the Indian Government of an order prohibiting the exportation from British India of tungsten and wolframite or any other ore of tungsten, unless a permit in this behalf signed by the Chief Customs Officer is produced to the Customs Collector at the port of export in respect of such tungsten and wolframite and any other ore of tungsten, and unless such tungsten and wolframite or any other ore of tungsten is shipped in accordance with the terms of such permit.

ON Wednesday, December 8, the Faraday Society held a general discussion on "The Corrosion of Metals—Ferrous and Non-ferrous," at the Institution of Electrical Engineers, Victoria Embankment, W.C. The president, Sir Robert Hadfield, F.R.S., was in the chair. The discussion was preceded by the reading of papers by Mr. L. Aitchison, Dr. C. H. Desch, Dr. J. Newton Friend, Mr. W. E. Gibbs, Mr. B Lambert, Mr. A. Philip, and Mr. S. Whyte, after which there was a general discussion on the subject. Members of the Iron and Steel Institute and the Institute of Metals were also present.

THE principal scientific and professional associations, societies, and institutes have been asked to co-operate with the Advisory Council of the Privy Council who are dealing with the organisation and development of scientific and industrial research. The council of the West of Scotland Iron and Steel Institute have appointed a sub-committee to deal with this matter, who are inviting members to specify any branch of industry with which the Institute is interested which they consider is a subject for organised and scientific research. The members of the sub-committee are Mr. Herbert Beard (president), Mr. Walter Dixon (past-president), Mr. Thos. B. Rogerson (past-president), and Mr. C. H. Desch (vice-president).

IN accordance with the decision of the Government, arrangements have been made between the Army Council and the Ministry of Munitions for the transfer to the latter of responsibility for designs, patterns and specifications, for the testing of arms and ammunition, and for the examination of inventions bearing on such munitions. Instructions have therefore been given for the immediate transfer to the Ministry of Munitions of the Ordnance Board, Research Department at Woolwich, Experimental Establishment at Shoeburyness, and the War Office Inventions Department. In this connection the Army Council have placed the services of Major-General Du Cane, C.B., at the disposal of the Ministry of Munitions.

THE Board of Trade (Exhibitions Branch) has issued a notice calling attention to certain provisions of the Defence of the Realm Act, empowering the Minister of Munitions to prohibit, or impose restrictions on the holding of, industrial exhibitions and fairs during the war, in order to prevent the production of war material being prejudicially affected. In consequence, the forthcoming British Industries Fair will be confined to exhibits not likely to interfere with the output of munitions. It is stipulated that any firm who holds contracts for a Government Department will have to obtain the permission of the Department before exhibiting. Similar restrictions will be imposed on the holders of any other industrial exhibitions and fairs.

ON December 13, Mr. Llewelyn Williams raised the subject of steel moulders in the Army, by asking the Minister of Munitions whether he was aware that a number of moulders in the King's uniform were employed at a National Munitions factory; whether there were many local moulders out of work, and were available for and willing to work at the factory. Dr. Addison replied that the men referred to as having been released from the Army for work at a munitions factory were experienced steel moulders. Before these steps were taken it was ascertained that no suitable steel moulders possessing the requisite skill were on the registers of the Labour Exchanges in the district. There were many different classes of iron, steel and brass moulders, and these classes were not necessarily interchangeable.

THE MONOMETER MANUFACTURING COMPANY, LIMITED, of Whitehouse Street, Aston, Birmingham, have received a war contract for a battery of eighteen of the Monometer patent crucible furnaces of the tilting type for a newly-erected works. Several firms have lately placed orders for Monometer patent self-acting heat controllers to be fitted to their existing furnaces, including the Daimler Company, Limited, Coventry, and Chance Bros. & Company, Limited. Other orders are for tinning furnaces for coating wires and cables without oxidation, and the company's standard furnace for melting aluminium without crucibles, the latter being ordered by Wolseley Motors, Limited, Jos. Lucas, Limited, Birmingham, and Crompton & Company, of Chelmsford. The Peel-Conner Telephone Works, Limited, of Salford, have purchased a Monometer soft-metal furnace.

THE work of the Steel Committee was considered at a meeting of the Newcastle and Gateshead Chamber of Commerce. Dr. J. T. Dunn stated that 163 licences had been issued since the last meeting, making a total of 563, and that fees to date amounted to £65 17s. 5d. The work of the committee was proceeding quite satisfactorily. They had never had occasion to question any of the applications for licences excepting in an indirect manner, where merchants had certified as to the composition of the steel they had not produced. In these cases the committee had always referred back again to the makers of the steel, and insisted on having certificates from the makers before they allowed the steel to go out. The certificate had been altered to make it clear that steel containing tungsten, molybdenum, etc., must not be exported.

FOR some months after the war broke out the plumbago-mining industry in Ceylon was suffering very severely from the loss of the German and Belgian markets, and steps were taken by the Imperial Institute to induce users of plumbago in the United Kingdom to purchase the whole of their supplies from Ceylon. Recent statistics indicate that progress has already been made in this direction, for it is significant that the percentage of Ceylon plumbago exported to the United Kingdom during the first ten months of 1915 was considerably greater than in 1913. Moreover, the total exports to this country from January to October last year were more than double those of the corresponding months in 1914, and in addition, Russia is a large new purchaser. The most important use of plumbago is in the manufacture of steel works, crucibles, and it is gratifying to know that a source within the British Empire is available to supply the demands of our munitions works for the article in question.

AT the annual meeting of the Society of Engineers held in London, on December 13, under the presidency of Mr. Norton Scorgie, it was reported that the president's gold medal had been awarded to Mr. A. H. Barker, the Bessemer premium to Mr. A. Steiger, and Lacy premiums to Mr. S. G. Turner and Mr. F. Groves. Mr. P. Griffith was elected president, and Messrs. H. O. Adams, W. B. Esson, and W. N. Twelvetrees vice-presidents. The secretary reported a membership of 588, with 83 affiliated members. About 50 were on active service, and many more engaged on miscellaneous war work as befitted engineers, when the result of the war depended so largely on engineering science. With regard to the effort of the society to improve the status of professional engineers of all classes, considerable progress had been made in the preparation of a comprehensive scheme dealing with the professional qualifications, fees and etiquette of consulting engineers.

A BRITISH mission was recently appointed to visit the industrial districts in France and to report on the causes which have contributed to the enormous increase which has taken place in the production of munitions in that country. The mission consisted of Messrs. J. T. Brownlie, chairman of the Amalgamated Society of Engineers; F. Duckham, Ministry of Munitions; D. J. Shackleton, Labour Advisor, Ministry of Munitions; and A. M. Smith, secretary of the Engineering Employers' Federation, together with two engineering experts. The report, which has now been presented, contains much information of a valuable nature, and also observations and conclusions on the position generally. The general conclusions at which the mission have arrived are:—(a) The people of France realise that they are at war. (b) The one idea in the mind of all is to bring the war to a successful issue. (c) The spirit which dominates the nation has prevented difficulties arising in the manufacture of war material. (d) Loss of time is practically negligible. (e) No Trade Union restrictions exist at the moment. (f) Everything is done to increase production. (g) No limitation of profits exists, and no question in this respect has been raised by the workpeople. (h) The manner in which the employers in France have been able to acquire machinery and the initiative and energy displayed by them are beyond all praise. (i) In conclusion, it appears to the mission that the increase of production in France is due to one cause, and one only, and that is the patriotic enthusiasm which exists there.

"F.T.J." Bookshelf.

THE METALLURGY OF GOLD. By Sir THOMAS ROSE, D.Sc. (London: Charles Griffin and Company, Limited, Exeter Street, Strand, W.C. Price 22s. 6d. net.)

This work is now in its sixth edition, and has been considerably expanded and revised in keeping with recent developments of practice. The volume is larger than formerly and comprises about 600 pages, including 223 illustrations. The author has given an excellent account of the extraction of gold from its ores and its adaptation for use, but he has also given much information which will be valuable to those engaged in the work and who are attempting to improve existing practice. Comprehensive and accurate information as to the properties of gold, its alloys and compounds, and of the bearing of these on the work to be done, is presented, and an extremely valuable chapter deals with the refining of gold and assaying. The electrolytic processes of refining is also carefully discussed. The volume may be accepted as a really valuable one to all those who are engaged in gold mining and working.

THE "MECHANICAL WORLD" POCKET DIARY AND YEAR BOOK, 1916. (Manchester: Emmott and Company, Limited, 65, King Street. Price 6d. net.)

This handy little annual again includes various new features. The section on steam boilers has been largely re-written, and much additional information introduced. A separate section is now devoted to the Diesel engine, and other improvements have been made. The "Electrical" companion to the above, published at the same price, has also some new features, including a lengthy section on switch gears and switch boards, and other matters.

Deaths.

MR. Z. MERTON, chairman of H. R. Merton and Company, Limited, died on November 29 last, at the age of 72.

MR. J. P. LEES, one of the original directors of H. Lees and Sons, Limited, Park Bridge Ironworks, Ashton-under-Lyne, died recently at the age of 84 years.

MR. G. P. WINCOTT, a director of G. P. Wincott, Limited, engineers and furnace builders, Attercliffe Road, Sheffield, died on November 22, at the age of 57 years.

THE death is reported of Mr. F. W. Manson, chairman of Richard Hill & Co. (1899), Limited, of the Newport Ironworks, Middlesbrough.

MR. H. MYER, of H. Myer & Company, Limited, Surrey Ironworks, 83, Vauxhall Walk, Lambeth, S.E., died on January 1, at the age of 65 years.

THE death has occurred suddenly of Mr. R. S. Rowell, the representative on Newcastle Quayside of R. and W. Hawthorn, Leslie and Company, Limited.

THE death took place at a nursing home on December 17 of Mr. John Wotherspoon, ironmaster, late of the Etna Iron & Steel Company, Limited, Motherwell, and the Cairns, Cambuslang.

MR. T. HATTERSLEY, head of the firm of Hattersley Brothers, Queen's Foundry, Swinton, has died in a nursing home at Bournemouth. Mr. Hattersley was 75 years of age, and highly respected in the Doncaster district, where he had resided for many years.

CAPTAIN AND ADJUTANT JAMES LUCK, 6th Batt. the Cameronians (Scottish Rifles) (T.F.), and a Chevalier of the Legion of Honour, has died from wounds received in France. The deceased officer was a director of David Colville & Sons, Limited, Dalzell Steel and Ironworks, Motherwell.

THE death took place recently at the age of 73 years of Mr. H. A. Allport, J.P., of Barnsley and Bournemouth, who, with Mr. R. Dalgleish, established the Holwell Iron Company, Limited, of Asfordby, near Melton Mowbray.

THE death took place at Greenock recently of Dr. Robert Caird, of the Clyde shipbuilding and engineering firm of Messrs. Caird and Company. He was the fourth son of the late Mr. James T. Caird, and had been associated with the firm all his business life. Dr. Caird rose to a distinctive position in his profession, and was an ex-president of the Institution of Engineers and Shipbuilders in Scotland, while his great scientific attainments were recognised by the University of Glasgow, in 1900, when the honorary degree of Doctor of Laws was conferred on him.

MR. F. H. LLOYD, J.P., Stowe Hill, Lichfield, died on January 4. Born in 1844, he was the son of the late Mr. Sampson Lloyd, J.P., of the firm of Lloyd, Foster & Company, now the Patent Shaft and Axletree Company, Limited. After leaving college, Mr. F. H. Lloyd took an active part in the control of that firm, having charge of the Bessemer steel department. He continued the head of the department under the Patent Shaft and Axletree Company, Limited, to whom the business was transferred in 1867. Mr. Lloyd severed his connection with the company in 1874. For some years he was connected with the extensive ironworks and collieries of the Darlaston Steel & Iron Company, Limited, and afterwards built the steel foundry at James Bridge, of which he was the sole proprietor. In 1888 the business was transferred to a private company, of which he was the chairman. Since that time the business has grown to large proportions. Mr. Lloyd was also chairman of the Weldless Steel Tube Company, Limited, Birmingham.

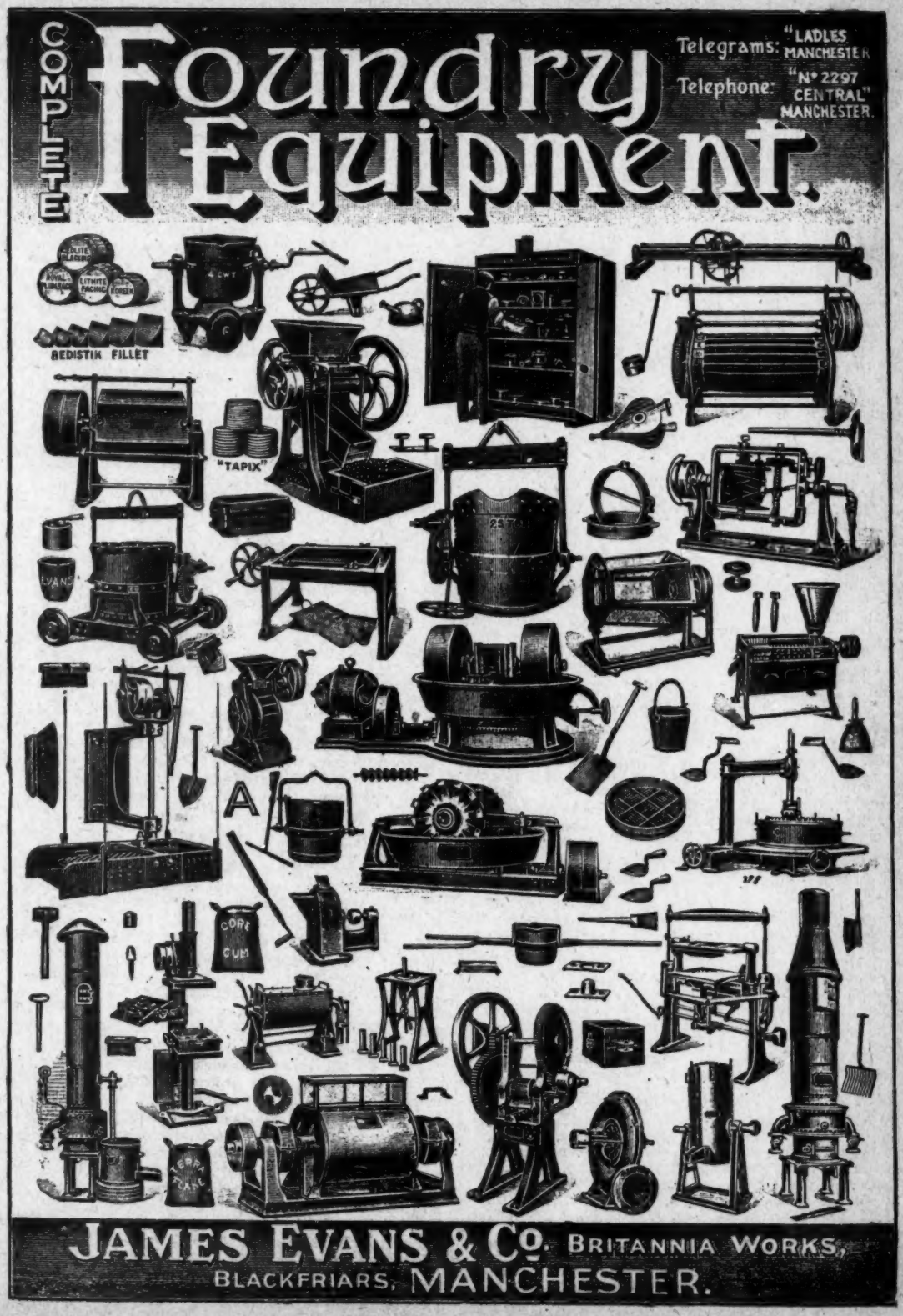
WE regret to announce the death, on November 20, at Seraing, Belgium, of Mr. Adolphe Greiner, director-general of the Soc. Anon. John Cockerill, of Seraing, and president of the Iron and Steel Institute, in his 72nd year. The deceased gentleman was born in Brussels in 1843, and was educated at the University of Liège. In 1864 he obtained the diploma of mining engineer at the School of Mines of the University, and immediately joined the Cockerill Company as engineer-chemist, which company had been the first on the Continent to adopt the Bessemer process. When M. Greiner took charge of the laboratory, the greatest difficulties were being encountered in the working of the Bessemer process, and when Mr. George Pastor, son of the then director-general of the Cockerill Works, took over the management of the steel works, he stipulated that he should have the co-operation of Mr. Greiner. Shortly afterwards the steel works, which had been shut down for some months, were again put in operation, this time with more profitable results. In October, 1869, Mr. Greiner was appointed to replace Mr. George Pastor as manager of the steel works; and in 1887, the Cockerill Company offered him the post of director-general, in succession to Baron Sadoine. For 29 years Mr. Greiner had the supreme direction of the affairs of the company, with its vast establishments and working population. Mr. Greiner was responsible for the introduction into the Cockerill works of three very important innovations—the basic process for steel making, the utilisation of blast-furnace and coke-oven gas, of which he was one of the earlier promoters, and the general employment of electric energy for the transmission of power to all parts of the works. Industrial education claimed a great deal of his attention. Schools were established at Seraing and Hoboken, and mining classes and others in the vicinity of Liège. Old-age pensions were introduced by him in 1892 for the benefit of the staff and workmen, and in 1908 he instituted pensions for widows of workmen who had served 25 years with the company. He was elected president of the Iron and Steel Institute in May, 1914, having been for many years a member of the council and vice-president. In 1913 he was awarded the Bessemer Gold Medal. At the Leeds meeting of the Institute in 1912 the University of Leeds conferred upon him the honorary degree of Doctor of Science.

Inventions.

Applications for Patents.

An asterisk indicates that a complete specification accompanies the application. When inventions are communicated the names of the communicators are in brackets.

16,110. Furnace for melting metals. H. N. Davis and W. R. Twigg.
16,359.*Metallic body consisting principally of aluminium. A. J. de Montby.
16,394. Tilting crucible furnaces. Alldays & Onions Pneumatic Engineering Company, Limited, and E. W. Nicholson.
16,403. Melting-furnaces. L. C. Harvey.
16,562.*Production of tungsten from scheelite. J. C. Butterfield and A. Ashworth.
16,576. Chilled castings. J. H. Swift.
16,597.*Manufacture of metal hydroxides. M. Buchner.
16,602.*Electric furnaces. F. Cochlovius.
16,729. Oil-fired metal-melting furnaces. A. D. Hunter and H. W. Cullum.
16,730.*Apparatus for the electrolytic production of zinc copper, etc. M. Perreur-Lloyd.
16,739. Moulds for casting brake-blocks. W. E. Williams.
16,801. Method of casting shells. T. W. Jopling.
16,814. Electric steel and alloy making and refining processes. J. R. Hyde.
17,022.*Electric furnaces. Aktiebolaget Elektriska Ugnar.
17,062. Electric furnaces. H. A. Greaves and H. Etchells.
17,165. Melting-furnaces of the crucible type. I. Hall.
17,186. Extraction of tungsten from the ore. J. C. Butterfield and A. Ashworth.
17,523. Production of iron or steel. T. Rouse.
17,543.*Regenerative gas furnaces. E. W. Harvey.
17,648. Casting metals and alloys. Sterling Metals Limited and E. Player.
17,651. Producing cores for and casting "stick" and like bombs and substantially spherical bodies and hollow-ware generally. J. N. Chadwick.
17,902. Crucible furnaces. J. Keith and G. Keith.
17,911.*Tyre-moulding machines. J. H. Coffey and J. H. Coffey, Jun.
17,971. Furnaces. I. Hall.
18,072. Firing gas furnaces. J. Keith and G. Keith.
18,090. Manufacture of steel. C. H. F. Bagley.
18,115.*Alloy for arc welding. D. H. Wilson and S. M. Rodgers.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Telegrams: "LADLES MANCHESTER"
Telephone: "No 2297 CENTRAL" MANCHESTER.
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"TAPIX"
JAMES EVANS & Co. BRITANNIA WORKS,
BLACKFRIARS, MANCHESTER.

Personal.

THE late Mr. Henry Steel, of Tapton Court, Sheffield, steel manufacturer, left estate of the gross value of £652,44 10s. 7d.

MR. J. H. B. FORSTER has been elected managing director of the Weardale Steel, Coal, and Coke Company, Limited.

THE late Mr. R. Scott, proprietor of the Winlaton Iron Works, left estate valued at £3,249 gross.

THE late Mr. H. Smith, of Keighley, Yorks, and of Dean, Smith & Grace, Limited, machine-tool makers, left estate valued at £38,955 gross.

THE late Major John Francis Selby Lloyd, a director of the Weldless Steel Tube Company Limited, has left property of the value of £7,443, the net personalty being £4,037.

MR. ROBERT WILLIAMS, of the Boston Lodge Locomotive Works, Portmadoc, has been appointed as general manager of the munitions factory established in that district.

SIR JOHN S. RANDLES, M.P., chairman of the Workington Iron and Steel Company, Limited, has been elected a director of the Star Assurance Society.

SIR ROBERT HADFIELD, F.R.S., and the Right Hon. Ellis J. Griffith, K.C., M.P., have joined the board of directors of the Mond Nickel Company, Limited.

THE personal estate of the late Mr. C. C. Scott, chairman of Scott's Shipbuilding and Engineering Company, Limited, Greenock, has been valued at £137,360.

THE late Mr. J. Barr, of the firm of Glenfield & Kennedy, Limited, left personal estate in the United Kingdom valued at £6,823.

THE late Mr. George Senior, J.P., chairman of George Senior & Sons, Limited, and of the Tinsley Rolling Mills Company, Limited, left estate valued at £76,430 gross.

THE gross value of the estate of the late Mr. J. Sagar, chairman of J. Sagar and Company, Limited, and a past president of the Halifax Engineering Employers' Federation, is £93,853.

PROBATE has been granted by the will of Mr. J. E. Maddock ironfounder, of Eastfield, Roslyn Road, Wellington, Salop, who died on October 19 last. Deceased left estate of the gross value of £8,348 4s. 4d., of which £7,984 18s. 2d. is net personalty.

MR. G. CARTER, formerly of Elswick, and now managing director of Cammell, Laird and Company, Limited, Birkenhead, is the new president of the executive board of the Shipbuilding Employers' Federation, and Mr. W. H. Dugdale, managing director of S. P. Austin and Son, Sunderland, is one of the vice-presidents.

MR. JAMES CURRIE has been appointed to give effect to the policy of the Labour Supply Department of the Ministry of Munitions in relation to the training of munition workers.

THE Minister of Munitions, it is announced, has appointed Mr. Seebohm Rowntree to assist Lord Murray on problems arising out of the employment of women as munition workers.

MR. J. M. FALKNER has been elected chairman of Sir W. G. Armstrong, Whitworth & Company, Limited, in succession to the late Sir Andrew Noble, Bart. Mr. Falkner was formerly private secretary to Sir Andrew Noble. About fifteen years ago the late baronet was incapacitated by a serious cycling accident, and a heavy responsibility fell upon his secretary. His great ability was recognised by an appointment to a seat on the directorate of Armstrong, Whitworth & Company. Two years ago he was elected vice-chairman.

THE New Year Honours granted by his Majesty have more than usual interest for the iron and steel industry, many prominent members being honoured this year. The Duke of Devonshire, who has been appointed Knight of the Order of the Garter, is chairman of the Barrow Hematite Steel Company, Limited, and a past-president of the Iron and Steel Institute. A barony of the United Kingdom has been conferred upon Admiral Lord Charles Beresford, M.P., chairman of John Henry Andrew & Company, Limited, Toledo Steel Works, Sheffield; and on Mr. D. A. Thomas, a director of the Ebbw Vale Steel, Iron and Coal Company, Limited. The new baronets include Sir George Bullough, a director of Howard & Bullough, Limited, and Mr. A. F. Yarrow, head of the well-known firm of shipbuilders and engineers, Yarrow & Company, Limited. A knighthood has been conferred upon Mr. George Franklin, a director of the British Thomson-Houston Company, Limited.

Legal Intelligence.

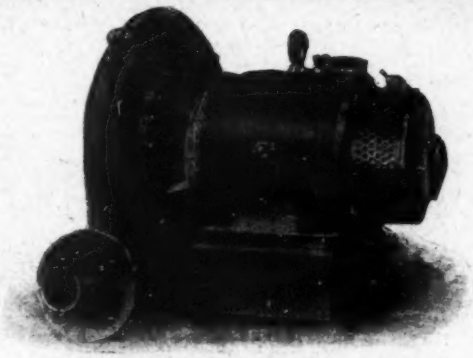
Wellman, Seaver and Head *v.* Skinningrove Iron Company.

An action was commenced on December 14 before Mr. Pollock, one of the Official Referees of the High Court, in which Wellman, Seaver & Head, Limited, of London, steelworks engineers and contractors, claimed a sum of £25,982 9s. 1d. from the Skinningrove Iron Company, Limited, of Carlin How, Yorks, being balance of the original contract price and various extras. The original contract, which was made in August, 1912, at a price of £58,000, consisted of two 60-ton Wellman tilting furnaces, together with chimneys, buildings, platforms and foundations. In October, 1912, however, the plaintiffs alleged that the defendants decided to change the design of the furnaces to make them capable of holding 120 tons of steel and to be suitable for working their system of the Talbot continuous process. As this involved extra weight, a new contract was made on a weight basis, and the plaintiffs' claim in this respect formed the principal item in their account for extras. The defendants also ordered in December, 1912, an extra extension of 14 feet 6 inches on the building and platform together with foundations for same. The plaintiffs alleged that these later contracts were in writing. An arrangement had recently been made between the parties by which the plaintiffs had agreed to withdraw a claim for damages in respect of delay caused by the alterations ordered by the defendants, and by encumbrances on the site, amounting to £5,750, and the defendants had agreed to withdraw practically the whole of their counterclaim, which amounted to approximately £9,000, with the exception of one item amounting to £780 for bottoming the furnaces.

Regarding the extra weights of the furnaces, the defendants contended that this was necessitated by defects in the plaintiffs' original design, but for the plaintiffs, counsel claimed that that reason was not put forward when the new contract on a weight basis was made.

During the opening of the case by Mr. Colefax, Mr. Barnard Lailey, on behalf of the defendants, admitted liability for items amounting to £5,200. The evidence of Mr. Benjamin W. Head, managing director of the plaintiff company was being taken when the court adjourned for the Christmas vacation.

Metals Consumed in Shell Manufacture. — The demands of manufacturers of shrapnel and other shells and rifle cartridges constitute a most important item in the consumption of copper, spelter, etc. A British 18-pounder, or 3.3-in. shrapnel, requires 5 lbs. 9⅓ oz. of brass, containing 66 to 70 per cent. Cu, or nearly 3¾ lbs. A small copper band around the shell adds 4¼ oz., making the total copper 4.04 lbs. Spelter consumption per shell of this size is about 1.87 lbs. Lead bullets weighing 7.92 lbs., and composed of 7 parts Pb to 1 Sb, constitute the metal load of the projectile. Estimating the total orders for shrapnel and other shells placed in the United States by Europe at 25,000,000 shells, these orders would call for a total of 101,000,000 lbs. of copper, 46,750,000 lbs. of spelter, and 173,250,000 lbs. of lead. Actually the metal consumption is larger, as a fair proportion of the shells are 4.7-in. howitzer shells, using more brass; some 6-in., 7½-in., and probably 9-in. shells are also being made. Rifle cartridges are composed mainly of copper, there being 1 lb. of it used in making 24 Lebel cartridges, a type widely used by the French Army. Every 125 of these cartridges consume 1 lb. of spelter and a small amount of nickel. Steel consumption per shell varies more widely with the different types. A finished 3.3-in. shell contains 6 lbs. 15½ oz. of steel, the steel shell weighing 6 lbs. 5½ ozs., and the diaphragm 9½ oz. If the shell is made from a steel bar, the weight of this is about 17 lbs., while a forging for the same purpose weighs approximately 14¼ lbs., and a "bottle" made by the seamless tube process, somewhat less.



10 H.P Fan and Motor.

TRADE SIROCCO MARK

High Pressure Fans

Are made in a large number of sizes from 10 in. diameter upwards.

Bulletins 2000 F. and 2028 F.

Some Points worth noting.

Owing to few wearing parts, the Fans are not liable to break down. The mechanical efficiency is high and remains so. The pressure is steady and the volume even and free from pulsations.

Davidson & Co., Ltd.,

Sirocco Works,
BELFAST.

ELDER'S FOUNDRY COKE

AS SUPPLIED TO THE
BRITISH
ADMIRALTY DOCKYARDS.

The following, selected from numerous letters, are eminent testimony as to the quality of our celebrated "A.A.A." Coppee Foundry Coke, carefully selected, and despatched in sheeted wagons.

From PECKETT & SONS, Bristol.

Bristol, October 25th, 1901.

We have been using your Selected Foundry Coke for some considerable time.
We have pleasure in stating that we are very pleased with it, as we find we get sounder and cleaner castings, more free from blowholes and other defects, than we formerly did.

From BOW, McLACHLAN & CO., LTD. (Paisley Foundry), Paisley, Glasgow.

Paisley, 12th March, 1909.

We have yours of 4th inst., and in reply have pleasure in stating that we have been using your Foundry Coke for several years for special purposes with highly satisfactory results.

Celtic Collieries, Ltd., Cardiff.

Telegraph: "OUTPUT, CARDIFF." Telephone: 4640 & 4641.

New Companies.

Clifford Perkins, Limited.—Capital £10,000 in £1 shares, to carry on the business of ironfounders.

Mid-Cornwall Munitions Company, Limited.—Capital £7,500 in £1 shares.

Low Moor Munitions Company, Limited.—Capital £50,000 in £1 shares. Registered office: Low Moor, Bradford.

Swindon Engineering Works, Limited.—Capital £10,000 in £1 shares.

Dawson and Downie, Ltd.—Capital £25,000 in £1 shares to carry on the business of engineers, brass and iron founders, etc. Registered offices: Elgin Works, Clydebank.

Metal Smelters, Limited.—Capital £1,000 in £1 shares. Registered office: Amberley House, Norfolk Street, London, W.C.

Curran Metals and Munitions Company, Limited.—Capital £30,000 in £1 shares. Registered office: Hurman Street Docks, Cardiff.

Arcorundum Abrasives, Limited.—Capital £2,000 in £1 shares, to carry on the business of manufacturers of abrasive materials, engineers, etc.

R. W. Munro, Limited.—Capital £10,000 in £1 shares, to carry on the business of mechanical engineers, etc. Registered office: 103 to 149, Cornwall Road, South Tottenham.

Phœnix Castings, Limited.—Capital £2,500 in £1 shares, to take over the business carried on by R. A. Munden and C. Perks, at Coventry, as the Phœnix Foundry Company.

Garrad Engineering and Manufacturing Company, Limited.—Capital £20,000 in £1 shares (500 for distribution). Registered office: 17, Grafton Street, W.

T. B. Kitchener & Company, Limited.—Capital £15,000 in £1 shares (5,000 6 per cent. cumulative preference), to carry on the business of engineers, etc. Registered office: Blackbird Street, Potton, Beds.

Anglo-Russian Engineering Company, Limited.—Capital £5,000 in 4,000 10 per cent. preference shares of £1 and 20,000 ordinary shares of 1s. Registered office: 78, Turnmill Street, E.C.

Smillie & Company, Limited.—Capital £10,000 in 9,000 participating non-cumulative preference and 1,000 ordinary shares of £1 each, to acquire and carry on the business of coppersmiths and brassfounders at Havelock Works, Glasgow and Belfast. Registered office: 71, Lancefield Street, Glasgow.

Caledonian Foundry Company, Limited.—Capital £5,000 in £1 shares to acquire the business of the Caledonian Foundry Company, Limited, Trafalgar Street, Greenock. The first directors are W. Graham, W. G. Riddell, J. Ferguson, J. Steel and A. R. Prentice.

Drypool Engineering Company (Hull), Limited.—Capital £3,000 in £10 shares to take over the business of engineers, etc., carried on as the Cleveland Engineering Works, at Wilson Street (off Clarence Street), Hull. T. Tate is the first managing director.

Keeton & Skinner, Limited.—Capital £5,000 in £1 shares, to take over the business of engineers and machinists carried on by Messrs. R. E. Keeton and J. E. Skinner, at the Attercliffe Engineering Works, Attercliffe Road, Sheffield, as Keeton & Skinner. The first directors are P. Keeton, R. E. Keeton and J. E. Skinner.

Fredk. R. Butt & Company, Limited.—Capital £7,500 in £1 shares, to take over the business carried on by H. F. Bigge, F. R. Butt, J. H. Webb and P. C. Kent at 147, Wardour Street, W., as Fredk. R. Butt and Company, and to carry on the business of scientific and general electrical engineers, etc. The first directors are H. F. Bigge and F. R. Butt (both permanent). H. F. Bigge is the first managing director. Registered offices: 147, Wardour Street, W.

The Electrical Manufacturers Company of Great Britain, Limited.—Capital £12,000 in £1 shares, to carry on business in Russia or elsewhere, and to adopt an agreement with Bruce Peebles & Company, Crompton & Company, the Lancashire Dynamo & Motor Company, Allen West & Company, Brook, Hirst & Company, Eckstein, Heap & Company, and Whipp and Bourne. The first directors are J. H. Bunting, E. H. F. Reeves, H. C. Siddeley, W. J. Moggridge, J. A. Hirst, A. Eckstein and S. Whipp. These are the respective nominees of the firms above named. Registered office: 23, Victoria Street, S.W.

Established 1863.

JAS. DURRANS & SONS,

Phœnix Works, Penistone, Near Sheffield.

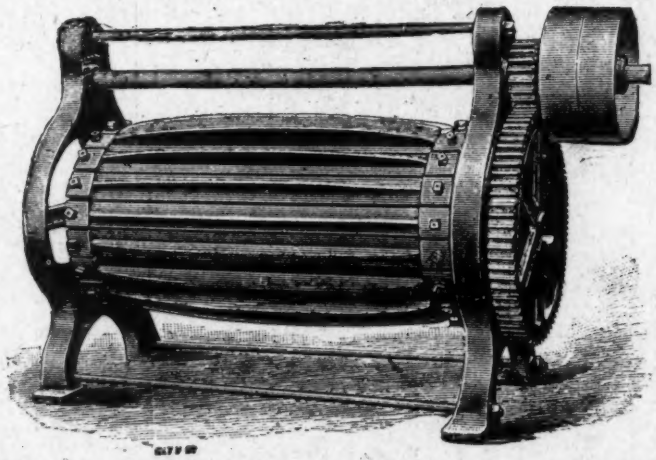
Manufacturers of all

FOUNDRY EQUIPMENTS

COMPOSITION BLACK LEAD, PLUMBAGO, CORE GUM, WHITE DUST & COAL DUST

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

Improved Foundry Rattler or Fettling Drum.



These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

The following testimonial explains itself :—

"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight.

Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD.

MONTHLY PRICE LIST.

The undermentioned prices, unless otherwise specified, are those obtaining at the commencement of the current month.

Pig-Iron.

Cleveland.

	s.	d.
Cleveland No. 1	82	6
,, No 3	79	0
,, No. 4 foundry	78	6
,, No 4 forge	77	6
,, Mottled	—	
,, White	—	
East Coast hematite, mixed Nos. ..	130	0
Cleveland warrants	78	5

Above prices are for early f.o.b. deliveries and as regards Cleveland iron are for G.M.B. brands. The warrant quotations are the sellers' cash prices.

Scotland.

	s.	d.
Standard Foundry (Glasgow Market settlement price)	78	1½
Warrants, ditto	84	6

Makers' prices :—

	s.	d.		s.	d.
Gartsherrie No. 1	103	6	No. 3	97	6
Coltness No. 1	113	6	No. 3	98	6
Summerlee No. 1	102	6	No. 3	97	6
Langloan No. 1	102	6	No. 3	97	6
Calder No. 1	102	6	No. 3	97	6
Clyde No. 1	103	6	No. 3	97	6
Carnbroe No. 1	96	0	No. 3	92	0
Monkland No. 1	93	0	No. 3	92	0
Shotts No. 1	102	6	No. 3	97	6
Govan No. 1	93	0	No. 3	92	0

(All deliverable alongside Glasgow.)

Glengarnock	No. 1	100	0	No. 3	95	0

(Deliverable alongside Ardrossan.)

Dalmellington	No. 1	97	6	No. 3	95	6
Eglington	No. 1	97	6	No. 3	95	6

(Deliverable alongside Ayr.)

Carron	No. 1	—		No. 3	—	

(F.a.s. Grangemouth.)

Scotch hematite, f.o.t. steelworks	132	6

Lancashire.

	s.	d.	s.	d.
Lancashire No. 3 foundry f.o.t.	—		—	
Lincolnshire No. 3 foundry ..	—		87	9
Derbyshire No. 3 foundry ..	—		85	0
Staffordshire No. 3 foundry	—		82	6
Cleveland No. 3 foundry ..	—		88	6

(All delivered equal Manchester.)

Scotch No. 3	Gartsherrie ..	—		
	Glengarnock ..	—	108	0
	Eglington ..	—		
	Summerlee ..	—	108	0

(Delivered Manchester Docks.)

North-West of England.

	s.	d.	s.	d.
Bessemer mixed numbers net f.o.b.	—		137	6
Hematite warrants net cash ..	—		115	0
Lorn cold-blast charcoal iron	—		—	

The Midlands.

		s.	d.	s.	d.
Staffs.	Common forge ..	—		75	0
	Part Mine forge ..	79	0	81	0
	Best All Mine ..	—		140	0
	Cold Blast	—		160	0

Strong forge, about 1s. less than grey forge; Mottled and White, about 2s. less than forge; Foundry No. 3, 3s. to 5s. above forge; No. 1 and No. 2, from 1s. 6d. to 2s. above No. 3; No. 1, about 2s. above No. 2.

Northampton foundry ..	—		82	6
North Staffs. foundry ..	—		—	
Derby foundry	82	6	85	0
Nottinghamshire foundry ..	—		—	
Leicestershire foundry ..	—		84	0
Shropshire Cold-Blast	—		160	0

(Delivered South Staffordshire Works, net cash monthly.)

Lincolnshire.

	s.	d.	s.	d.
Forge	—		82	6
Grey forge	—		82	6
Basic	—		—	
No. 3 foundry	84	0	85	0
No. 4 foundry	—		—	

F.o.t. Makers' Works.

South Wales.

	s.	d.	s.	d.
Welsh Hematite	—		145	0

Ferro-Alloys.

Net, Delivered Sheffield steel works.

	£	s.	d.
Ferro chrome : 4/6% carbon. Basis 60%, scale 10s. per unit. Per ton	35	0	0
Ferro-chrome : 6/8% carbon. Basis 60%, scale 10s. per unit. Per ton	29	10	0
Ferro-chrome : 8/10% carbon. Basis 60% scale, 10s. per unit. Per ton	28	0	0
Ferro-chrome : Specially refined, guaranteed maximum 2% carbon, broken to small pieces for use in best quality crucible steels. Basis 60%, scale 32s. per unit. Per ton	86	0	0
Ferro-vanadium : 33/40% Va., perib. of Va. contained in the alloy ..	0	14	0
Ferro-silicon : 45/50%. Basis 50%, 5s. scale per unit .. Per ton	27	10	0
Ferro-titanium : 23/25%, per pound carbonless	0	1	9
Ferro-molybdenum : 70/80% Mo. per pound of Mo. contained ..	0	18	0
Ferro-phosphorus : 20/25%. Per ton	16	10	0
*Ferro-manganese 80%	20	0	0
,, export	—		

* F.o.b. Liverpool.

Iron Castings.

Cleveland.

	£	s.	d.	£	s.	d.
Columns (plain) ..	—			to	—	
Pipes, 1¼ to 2½ in. ..	—				—	
,, 3 to 4 in. ..	—				—	
,, 5 to 8 in. ..	—				—	
,, 10 to 16 in. ..	—				—	
,, 18 to 24 in. ..	—				—	
Chairs	—				—	
Floor plates (open sand)	—				—	

(At work.)

Non-Ferrous Metals.

Copper.

	£	s.	d.	£	s.	d.
Standard, Cash	85	0	0	85	5	0
Three months	85	0	0	85	5	0
Electrolytic	113	0	0	115	0	0
Tough	107	0	0	108	0	0
Best selected	108	0	0	109	0	0

Tin.

Standard, Cash	173	0	0	173	10	0
,, Three months	174	10	0	175	0	0
English Ingots	—			175	0	0
Bars	—			176	0	0
Refined	—			178	0	0

Spelter.

American	—	90	0	0
Specials	—	—		
Hard	—	65	0	0
British	—	75	0	0

Lead.

Soft Foreign	—	31	0	0
English	—	31	15	0

Antimony.

Regulus	—	95	0	0

Aluminium.

Virgin Metal 98/99% per ton	155	0	0	200	0	0

*Chromium (Metallic).

98/99% purity, per lb.	—		—

*Nickel.

In cubes, 98/99% purity Per ton	220	0	0			

*Tungsten Metal Powder.

96/98% purity .. per lb. ..	0	5	10			

*Molybdenum Metal.

96/98% purity .. per lb. ..	—					

*Cobalt Metal.

97% purity .. per lb. ..	0	8	0			

Quicksilver.

75 lb. bottle	16	13	9			

* Net, Delivered Sheffield Works.

Scrap Iron and Steel.

Cleveland.

	s.	d.	s.	d.
Steel scrap, heavy melting ..	87	6	to 90	0
Iron scrap cast (cupola metal)	64	0	66	6

London (f.o.b.).

Heavy steel	75	0		
Light ,, ...	50	0		
Heavy cast	60	0		

Non-Ferrous Scrap.

London merchants quote the following prices for scrap metal, delivered London, and subject to market fluctuations :—

	A. Joseph. £	s.	d.
Hy. Electrolytic Copper Scrap ..	—		
Hy. Selected Scrap Brass ..	—		
Hy. Tinned Copper Wire ..	—		
Best Selected Gunmetal Scrap ..	—		
Re-melted Ingot Lead 30s. under English Lead price on date of order.			

Stocks.

Pig-iron in Public Store.

	Tons.	Inc. + or Dec. – since Dec. 31 1914. Tons.
Connal's at Glasgow Scotch	1,000	No change.
Ditto other makes ..	—	No change.
Connal's at Middlesbrough	113,492	+ 13,270
Connal's at Middlesbrough hematite ..	—	No change.
West Coast hematite	2,052	– 1,915

Metals

Copper, Europe and afloat	25,064	– 10,368
Tin, London, Holland, U.S.A. and afloat	17,022	– 708

Coke.

Middlesbrough.

	s.	d.	s.	d.
Gas Coke	Unobtainable.			
Foundry Coke	35	0	40	0
Furnace Coke	—		33	0

Newcastle-on-Tyne.

	F.o.b. s.	d.	Dunston. s.	d.
FOUNDRY COKE—				
Original Garesfield ..	—		36	0
Mickley	—		36	0
Stella Garesfield	—		36	0
Priestman's Garesfield ..	—		36	0
Consett Garesfield ..	—		36	0
Newcastle gas coke ..	—		29	0

Cardiff.

	s.	d.	s.	d.
Special Foundry Coke ..	42	6	to 45	0
Foundry Coke	35	0	to 42	0
Furnace Coke	33	0	to 36	0

Leeds.

Furnace Coke (washed) ..	—		24	0

Birmingham.

Foundry Coke	—		—	
Furnace Coke	—		—	
Gas Coke	30	0	33	0

Glasgow.

Foundry Coke	—		35	0
Furnace Coke	—		26	6
Gas Coke	—		—	

London.

Welsh or Durham Foundry, d/d London Stations, in truck	—		46	6
Yorkshire, d/d London Stations, in truck ..	—		36	6

SITUATIONS VACANT AND WANTED.

FOREMAN, with special experience in loam, for London iron-foundry engaged on Government work. Must be thoroughly experienced. No one already on Government work need apply.—Write, stating age, experience and salary required to your nearest Labour Exchange, mentioning this paper and No. A1314.

ENGINEER, 20 years' experience as foreman and works manager, wants responsible position; large and varied experience in high-class engines, air compressors, pumps, hydraulic, millwright, and general engineering.—Box 595, Offices of FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.

FOR SALE AND WANTED.

GANISTER for Cupolas, Furnaces, etc. Very best quality. On War Office List. Supplied to all leading Iron Works and Foundries. Established 30 years.—Astbury Silica Company, Newbold, Astbury, near Congleton (late Sankey & Hall). Communications to D. Boulton, Astbury Silica Company, Kidsgrove, Stoke-on-Trent.

STEAM HAMMER, self-contained, 5¾-in. cylinder, 14-in. stroke, by Woodhead; belt-driven power hammers, friction clutch, 60 lbs. blow, self-contained.–WIDDOWSON'S, Canal Street, Nottingham.

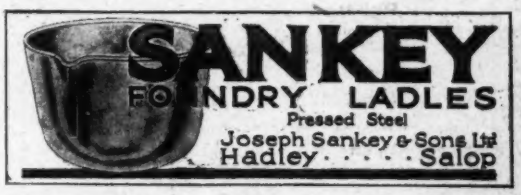
EXCELLENT Second-hand 2½-cwt. Belt-driven Pneumatic Hammer, by Alldays & Onions, Limited, with anvil block, etc., in very good condition. —MARPLE & GILLOTT, LIMITED, Sheffield.

5-TON Hand Swing Jib Crane, 17-ft. radius, 20 ft. high, with double-geared crab chains and return blocks, racking in-and-out motion, top fixing and foot step chains, recently tested to 5½ tons.—C. F. DAVIS, 18, Billiter Buildings, London, E.C.

ADVERTISER requires Quotations from Manufacturers of Foundry Requisites and General Mill Furnishing; good connection with engineers and iron-founders.—Apply, Box 597, Offices of FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.

FOR SALE.

FOR SALE.—24-in. Invincible Sand Mixer, capacity 3 tons per hour, for grinding, mixing and screening foundry sands, at lowest cost per ton.—Apply, HALL, 26, Paradise Square, Sheffield.

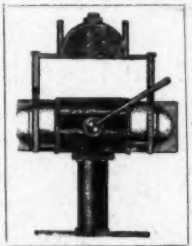


PATTERN SHOP SUPPLIES.

Wires: "Requisites, B'ham." J. BURN & CO., Phone: 137 Victoria.

HENSHAW ROAD, SMALL HEATH. BIRMINGHAM.

ARE YOU INTERESTED IN THE PRODUCTION OF CHEAP, ACCURATE CASTINGS?



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Telegrams: "ADAPTABLE." 'Phone: 1966 Mid.

GANISTER, CUPOLA BLOCKS, FIRE BRICKS,
FIRE CLAY.
Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.
STEEL MOULDERS' COMPOSITION, SILICA CEMENT.

J. GRAYSON LOWOOD & Co., Ltd.,
DEEPCAR, nr. SHEFFIELD.
Telegrams: "LOWOOD, DEEPCAR."

PLUMBAGO—CRUCIBLES.

Parting Powder.

William OLSEN,
Cogan Street, HULL.

FOUNDRY MATERIALS AND REQUISITES.

Largest Stock of Straw and Wood Fibre CORE ROPINGS.

Wax Core Vent.

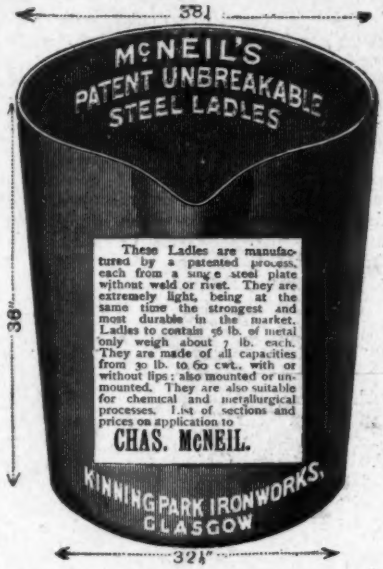
GLUTRIN—CORE GUM.

FANS AND BLOWERS AND OTHER FOUNDRY MACHINERY FOR SALE.

BARGAINS FOR PROMPT CASH.

No. – Root's Blower "Acme" for 20 smiths' fires.
One ditto with high-speed Vertical Engine combined.
Thwaites' Roots Blower, 11½" discharge.
"B" Roots Blower by Alldays.
4' dia. Impeller Lloyd's Blast Fan, for 100 smiths' fires.
14" Schiele patent Blast Fan.
Lloyd's patent Blowing Fan for 50 smiths' fires.
New Roots pattern Blower, 5".
Silent Blowing Fans, 8" and 9" discharge and New, 3" and 4", discharge.
Ball Mill, with drum, 2' 7" and 5' 8" outside by 1' 7" wide.
Improved Foundry Core Ovens portable type and for fixing in wall
4'0" diameter UNDERGEARED LOAM MILL, with stationary pan.

CHARLES D. PHILLIPS,
EMLYN & CENTRAL ENGINEERING WORKS, NEWPORT, MON.

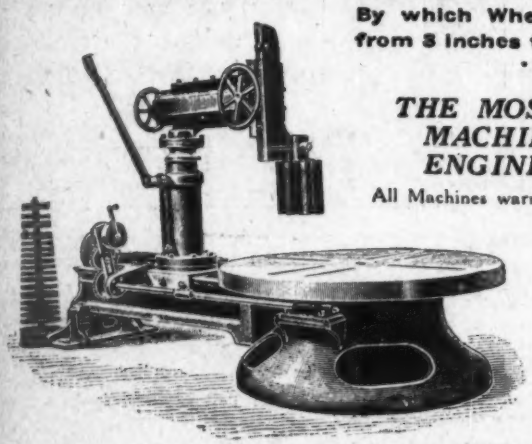

38½
McNEIL'S
PATENT UNBREAKABLE
STEEL LADLES
These Ladles are manufactured by a patented process, each from a single steel plate without weld or rivet. They are extremely light, being at the same time the strongest and most durable in the market. Ladles to contain 56 lb. of metal only weigh about 7 lb. each. They are made of all capacities from 30 lb. to 60 cwt., with or without lips; also mounted or unmounted. They are also suitable for chemical and metallurgical processes. List of sections and prices on application to
CHAS. McNEIL.
KINNING PARK IRONWORKS,
GLASGOW
36"
32½"

CAN ALSO BE MADE IN ALUMINIUM.

Kindly mention this paper when enquiring or ordering.

WHITTAKER'S IMPROVED MOULDING MACHINE

By which Wheels or Pulleys of any description or size from 3 inches to upwards of 20 ft. diameter can be made.



THE MOST COMPLETE AND EFFICIENT MACHINE HITHERTO INTRODUCED TO ENGINEERS.

All Machines warranted to Mould with the greatest accuracy and precision.

GEARING WHEELS

Spur or Bevel, Straight Teeth and Double Helical Teeth Supplied to Consumers.

ROPE & BELT PULLEYS.

WM. WHITTAKER & SONS, LTD.,

SUN IRON WORKS, *OLDHAM.*

Index to Advertisers.

Addresses, Telegraphic Addresses, and Telephone Numbers.

PAGE.	NAME.	ADDRESS.	TELEGRAPHIC ADDRESS.	TELEPHONE NO.
111	Adaptable Moulding Machine Co.	Stanhope Street, Birmingham	"Adaptable"	1966 Mid.
	Alldays & Onions, Ltd.	Birmingham	Alldays, Birmingham	38 Victoria
65	Anglo-Mexican Petroleum Products Co., Ltd.	Finsbury Court, Finsbury Pavement, E.C.	Mexproduct, Ave, London	City 2704
	Boam, Joseph, Ltd.	35, Silver Street, Leicester	Boam, Leicester, 399	Central 399
65	Braby, F. & Co., Ltd.	Petershill Road, Glasgow	Braby, Glasgow	—
C. iii.	Bradley, T. & I. & Sons, Ltd.	Darlaston	Bradley, Darlaston	—
	Bridge, D. & Co., Ltd.	Castleton, Manchester	Coupling, Castleton, Manchester	25 Rochdale
63	Britannia Foundry Co.	Coventry	Stoves, Coventry	251
	British Aluminium Co., Ltd.	109, Queen Victoria Street, E.C.	Cryolite, London	4315 London Wall
62	British Binderit Co., Ltd.	Wharf Road, Wandsworth, S.W.	Bindercomp, Wands., London	994 Putney
67	Broadbent, T. & Sons	Huddersfield	Broadbent	1581 (4 lines)
C. iv.	Buckley & Taylor, Ltd.	Castle Iron Works, Oldham	Engines, Oldham	Oldham No. 8
111	Burn, J. & Co.	Small Heath, Birmingham	"Requisites," Birmingham	137 Victoria
107	Celtic Collieries, Ltd.	Cardiff	Output, Cardiff	4640-1 Cardiff
C. ii	Cumming, William & Co., Ltd.	Maryhill, Glasgow	Prudence, Glasgow	P.O.M. 25
107	Davidson & Co., Ltd.	Belfast	Sirocco, Belfast	4341 Belfast
59	Davies, T. & Son	West Gorton, Manchester	Tuyere, Manchester	70 Openshaw
109	Durrans, Jas. & Sons	Penistone, nr. Sheffield	Durrans, Penistone	—
68-105	Evans, J. & Co.	Manchester	Ladles, Manchester	2297
C. ii.	Everitt & Co.	40, Chapel Street, Liverpool	Persistent, Liverpool	1134 Central (3 lines)
C. ii.	Fyfe, J. R., & Co.	Shipley, Yorks	Brick, Shipley	59 Shipley
	Glasgow Patent Moulders Blacking Co.	26, Fleming St., Port Dundas, Glasgow	Moulders, Glasgow	—
58	Goldendale Iron Co., Ltd.	Tunstall, Stoke-on-Trent	Goldendale, Tunstall, Staffs.	—
66	Gray, Thomas E. & Co.	3—4, Lincoln's Inn Fields, Kingsway, London, W.C.	Papplewick, Holb, London	1946 Holb.
C. ii.	Hall, John & Co. (Stourbridge), Ltd.	Fire Clay Works, Stourbridge	Hall, Stourbridge	55 Stourbridge
C. i.	Hedley Moorwood & Co., Ltd.	21, Church Street, Sheffield	Morod, Sheffield	4318
	Hislop, R. & G.	Paisley	Gas, Paisley	331 Paisley
63	Keith, James & Blackman Co., Ltd.	27, Farringdon Avenue, London	James Keith, London	6194 H'lb'rn (4 lines)
67	King Bros. (Stourbridge), Ltd.	Stourbridge	King Bros., Stourbridge	—
	London Emery Works Co., Ltd.	Prak, Tottenham	Naxium, London	9 Tottenham
111	Lowood, J. Grayson, & Co., Ltd.	Deepcar, nr. Sheffield	Lowood, nr. Sheffield	18 Stocksbridge
67	Mansergh, T. E.	Wheathill Charcoal Works, Salford	—	—
	Marshall, H. P. & Co.	Leeds	Speciality, Leeds	1309 Leeds
	Metalline Cement Co.	112, Bath Street, Glasgow	Adhesive, Glasgow	201 Y2 Douglas
112	McNeil, Chas.	Kinning Park, Glasgow	McNeil, Glasgow	X 155
61	Naish & Croft	150, Alma Street, Birmingham	—	—
112	Olsen, William	Cogan Street, Hull	Wm. Olsen, Hull	Nat. 1184
112	Phillips, Charles D.	Newport, Mon.	Machinery, Newport	—
C. iii.	Phillips, I. W. & C. J.	23, College Hill, E.C.	Colloquial, London	10112 Central
	Portway, Chas. & Son	Halstead, Essex	Portway, Halstead	10 Halstead
	Robson, E., Capper & Co., Ltd.	1, North Road, Darlington	Capper, Darlington	2405 National
108	Rowlands, T. & Co., Ltd.	North Church Street, Sheffield	"Titanicum," Sheffield	Central 4994
60	Samuelson & Co., Ltd.	Banbury	Samuelson, Banbury	17 Banbury
111	Sankey, Joseph & Sons, Ltd.	Hadley, Salop	Sankey, Hadley	—
57	Standard Sand Co., Ltd.	Mansfield	Standard Sand Co., Mansfield	201 Mansfield
61	Stewart, D. & Co., Ltd.	London Road Iron Works, Glasgow	Stewart, Glasgow	71 P.O. Bridgton & 3243 Bridgton (N.)
	Tilghman's Patent Sand Blast Co., Ltd.	Broadheath, nr. Manchester	Tilghmans, Altrincham	14
64	Thwaites Bros., Ltd.	Bradford	Thwaites, Bradford	3456 & 3460 Brdf'd
66	Universal Machinery Corporation, Ltd.	326, Old Street, London, E.C.	Toolcraft, London	3763 London Wall
61	Walker, I. & I.	Rotherham	—	—
	Walco, Ltd.	53, Newton Street, Birmingham	Walco, Birmingham	Central 3305
112	Whittaker, W. & Sons, Ltd.	Oldham	Whittakers Engineers, Oldham	83
67	Wilkinson, Thos. & Co., Ltd.	Middlesbrough	Blacking, Middlesbro'	419
61	Williams, J. (Birmingham Sand), Ltd.	Birmingham	—	—

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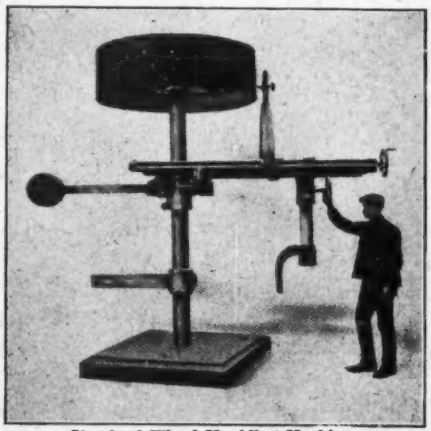

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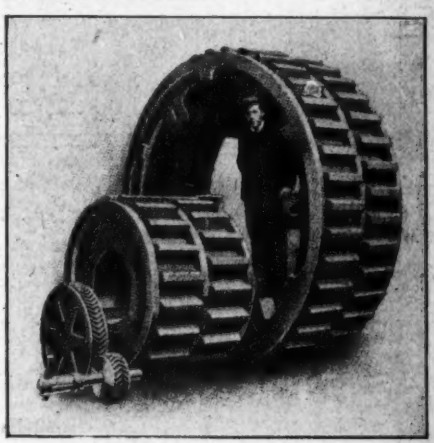

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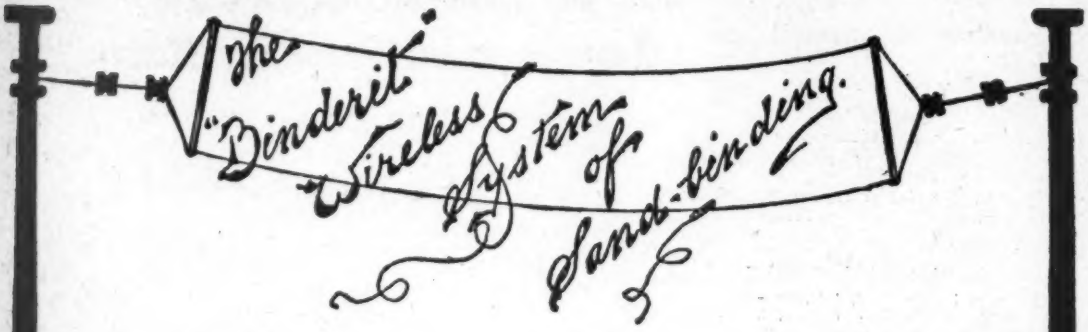

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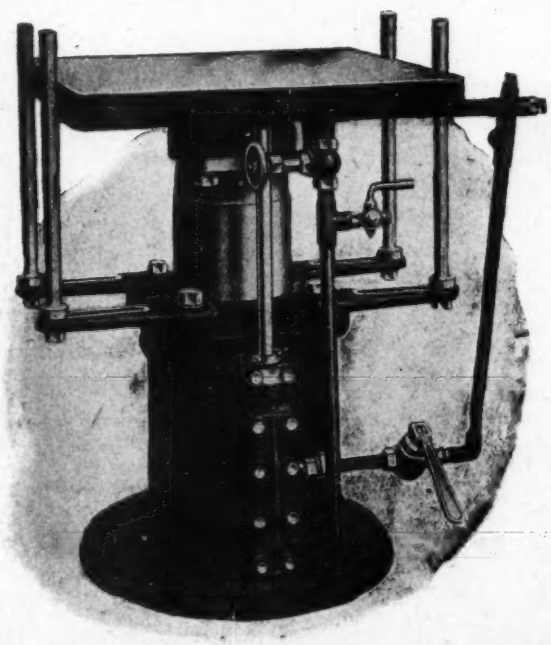

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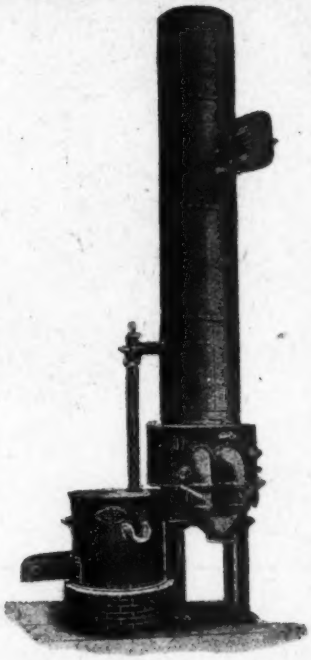

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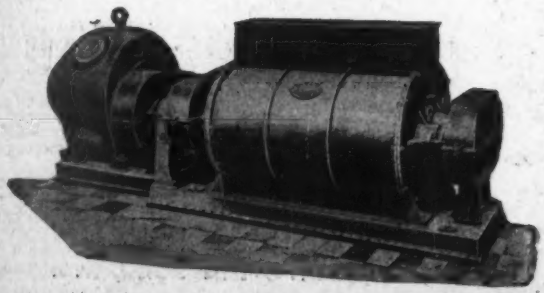

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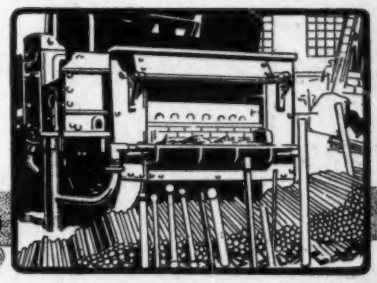

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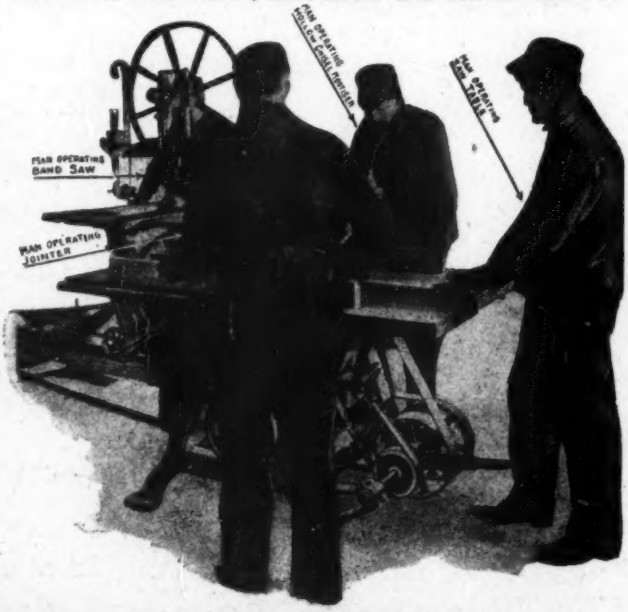

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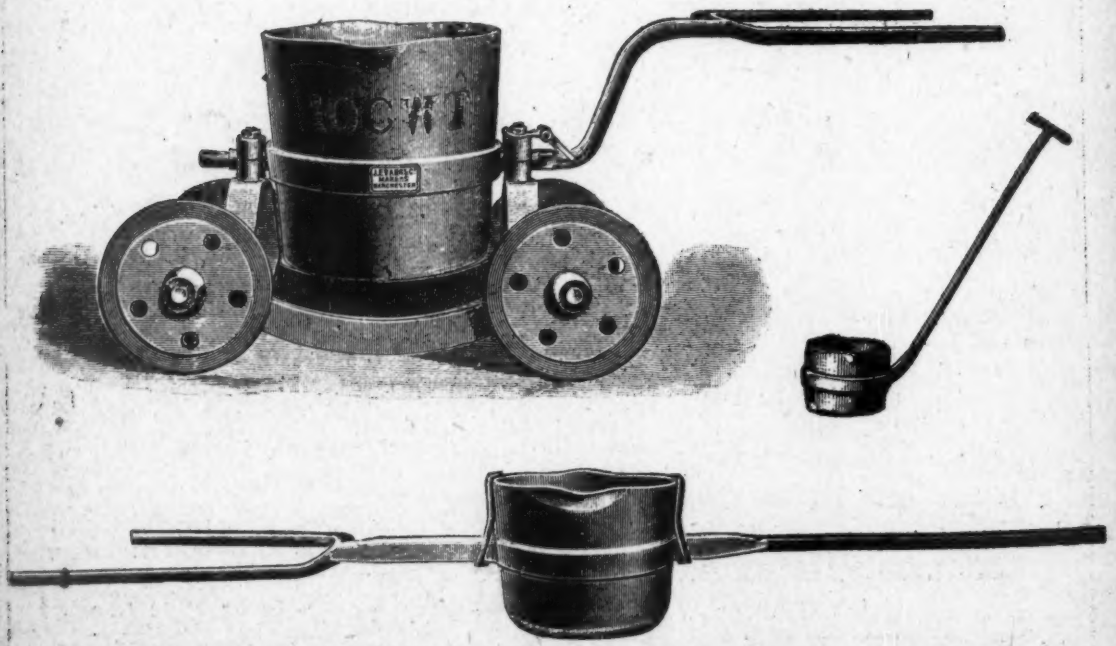

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